HYDROCARBON PROCESSING &
Petroleum
REFINER
SEPTEMBER 1961
FOR THE HYDROCARBON PROCESSING INDUSTRY

LATEST TRENDS IN REFINING SCHEMES

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Can Maintenance Be Controlled? 233
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NOW . . .

For a "Quick Look" at this issue, turn the page

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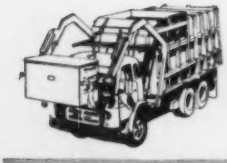

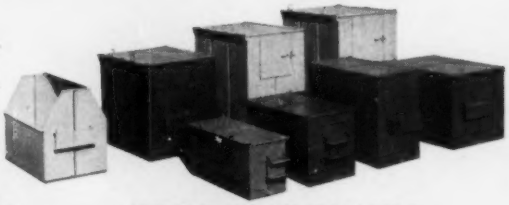

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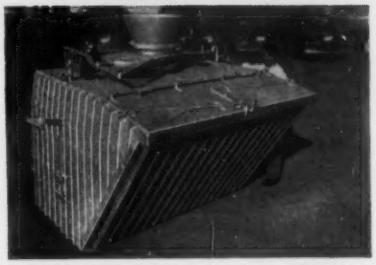

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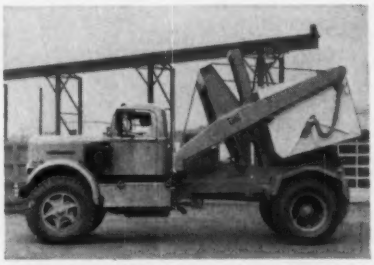
This 6 cu. yd. tilt-type container was specially built to store and handle a high-temperature dusty product. It has cooling fins, a counter-balanced spring-hinged lid and a 16" sliding gate valve. When full it is picked up, hauled and emptied by a Dempster-Dumpster. Details are contained in a free brochure entitled "Special Containers." Dempster Brothers, Inc., Knoxville 17, Tenn.



NEW LFW HANDLES CONTAINERS

This new LFW 603-C, mounted on a White Mustang, was produced to handle scrap metal storage containers. It will handle containers in capacities up to 15 cu. yds. in all Dempster-Dumpster models. Lifting capacity is 18,000 lbs. Dempster Brothers, Inc., Knoxville, Tenn., offers a catalog brief No. 160 describing this and other materials handling systems.

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This 2,000-gallon tank was produced for operation at temperatures as low as −90° F. It features its own pump and gasoline engine. Prime mover is a truck-mounted Dempster-Dinosaur which hydraulically lifts the tank into carrying position and puts it off. A new catalog section No. 12 describes the development. Dempster Brothers, Inc., Knoxville 17, Tenn.

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A Quick Look at This Issue

☐ **Want to Know What Hydrogen Costs . . .** Here is a new look at the economics of making hydrogen. Now you can make a closer study of two hydrogen making processes—steam reforming and partial oxidation, on **Page 163.**

☐ **Condensate Can Be Hydrocracked Too . . .** Together, Isocracking and catalytic reforming offer a worthwhile way to improve natural gasoline condensate. For an economic analysis of how these two processes go hand-in-hand, see **Page 167.**

☐ **New Reactor System Isomerizes C_5's . . .** Commercial and pilot plant tests demonstrate the success of a new reactor system for isomerizing pentane. Originally for butane isomerization, the new system is also shown to give high yields of isopentane on a single-pass basis. For details, turn to **Page 171.**

☐ **New Hydrotreating Now Commercial . . .** BP now has three units of their selective hydrogenation process installed with more on the way. See how the process upgrades the gasoline by-product from ethylene manufacture, on **Page 175.**

☐ **Big Revamp Yields a Modern Refinery . . .** Century recently completed a modernization program giving it a well-balanced refinery. For a report on what this refiner is doing to keep up to date, turn to **Page 179.**

☐ **Canada Gets BP's Newest Refinery . . .** British Petroleum's entry into refining activities of the Western Hemisphere is marked by the come-up of a new refinery near Montreal. Two-stage crude distillation, catalytic cracking, reforming, hydrogen treating and polymerization are the basic crude handling processes for this one. For details, see **Page 182.**

☐ **What Brazil Added to Its Refining . . .** These new processing units will up Petrobras' crude handling capacity at its Landulpho Alves refinery. To see the type of processing facilities included in this newly expanded refinery, turn to **Page 185.**

☐ **More Modern Route to Waxes and Lubes . . .** DX Sunray continues modernization steps at its Tulsa refinery. For a discussion of the over-all plan and a report on how each step is progressing, turn now to **Page 189.**

☐ **Use This Guide for Process Studies . . .** This convenient check list is tailored especially for those concerned with process development. However, personnel in process design and production investigation also may find it useful. Make sure you are not omitting important items in your process evaluation, by using this handy check list, beginning on **Page 195.**

☐ **Decide Easier About Multi-stage Units . . .** A poor decision about one stage of a multi-stage unit will affect each successive stage. It's important then for you to learn how "dynamic programing" will help make better allocation decisions easier. For ways to set up the equations, see **Page 201.**

☐ **New Charts for Hydrocarbon Vapor-Liquid Equilibrium . . .** Here are extensions, improvements and a consolidation of previous vapor-liquid equilibria correlations. The range is from —260 to 800° F for pressures up to 10,000 psia. Throw away your old correlations and make way for these new ones on **Page 207.**

☐ **A New Method for Equilibrium and Condensation Calculations . . .** Here's a better method for calculating the amount of vaporization or condensation for multi-component mixtures. Get this easy method for your notebook, on **Page 219.**

☐ **What's Your Interest Rate? . . .** Here's how to calculate, use and interpret the interest rate for a profit-making investment. You'll find this helpful for project evaluation and all economic work. Turn to **Page 221.**

☐ **Figure Superfractionation Fast . . .** These equations are streamlined for speed in making binary superfractionation calculations. For a look at how they handle varying relative volatilities and give speed without sacrificing accuracy, turn to **Page 227.**

☐ **Can Maintenance Be Measured and Controlled? . . .** "Every maintenance manager should accept this challenge and take steps to prove that he can measure, interpret and control maintenance operations." For details on how to measure and control maintenance with four basic steps, turn to **Page 233.**

☐ **Figure Separations This New Way (Part 5) . . .** Here's the fifth part in Dr. Holland's series that has developed such a fast and rigorous convergence method for making separation calculations. You'll find how he has adapted the Θ-method to absorbers, on **Page 237.**

☐ **Don't Be Confused by Rotary Pump Curves . . .** Some engineers throw up their hands in despair when a screw or gear pump operates at viscosities other than those shown on the curves. For a simple way to extrapolate rotary pump curves and find the operating characteristics at other viscosities, see **Page 249.**

☐ **Bright Outlook for Acrylics . . .** Lower processing costs, raw materials, better products and broader markets spell success for acrylics. For details on new acrylic developments and processes, turn to **Page 251.**

☐ **Thermo Data for Petrochemicals (Part 31) . . .** For your thermo data book here are more thermodynamic properties. This time Author Chermin presents data on the gaseous n-2-thia alkanes from dimethylsulfide through methyl-n-decasulfide. See **Page 261.**

☐ **Equipment Cost Data File (Part 6) . . .** Here's erected cost data for diaphragm tanks and expansion roof tanks. Add this to your estimating file, on **Page 267.**

☐ **Chances Are—You'll Be a Manager . . .** If you aren't already a manager or supervisor, you probably will be before long. It's almost a statistical certainty, and you'll get all the whys and wherefores in this interesting article starting on **Page 271.**

☐ **What You Should Know About Arbitration . . .** The word "arbitration" is becoming increasingly common on the American industrial relations scene. But do you really know the full details of what it is and how it works? If not, you will after reading this article, beginning on **Page 274.**

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A Feature Dolled Up

"HPI CONSTRUCTION BOXSCORE" received a somewhat different treatment in July's issue, as maybe you noticed—the boxes around maps designating the various geographic categories were eliminated and some new illustrations were made for foreign sections. Now each Boxscore category has a map.

Aside from dressing up the tabulation, it is our hope that the extra projections delineate more clearly the parts of the world Boxscore surveys. Incidentally, the feature set a record of 14 pages of solid tabulation in July's book, the largest the report has ever been.

"HPI Construction Boxscore" has been a regular feature in HP-PR for the past 14 years, and is the widest read and most comprehensive compilation of its kind for the hydrocarbon processing industry. It appears quarterly with the next presentation due in October. Thousands of readers check it each time both in the issue and in the form of a special reprint which has wide distribution.

Odd-Year Value

HP-PR's PROCESS DEVELOPMENTS ISSUE, which you now hold, is a near-perfect supplement to the well established Process Handbook Issue with which its alternates.

ITEM: Of the 90-plus process descriptions mentioned in the latest Handbook Issue (September 1960) more than half (58 percent) of them referred to articles published previously in HP-PR. All other magazines and references accounted for only 17 percent. So most of the contributors—men who make their living by selling processes and who have great interest in the success of process techniques—hold HP-PR in high regard as the best source of such detailed information.

ITEM: Another point, more applicable to the 1961 Developments Issue, is that 20 of these 90 processes (37 percent of the total citation to HP-PR) referred to articles in past PROCESS DEVELOPMENTS issues.

Q.E.D.—These issues of HP-PR are successful then at giving the kind of information that process men need. And this September number (issued in every "odd" year) is highly valued as a supplement to the Handbook Issue which appears every "even" year in the same month, September.

Demand for More

THEY LIVE LONG, SERVE WELL!—Letter came late in August from one of our authors, Robert L. Bates whose "How to Specify Agitators" had one of the top billings in our November 1960 issue. "At that time," he wrote, "we obtained 2000 reprints. The demand for these copies has been extremely heavy and we find that our supply is getting low. Would it be possible to obtain additional reprints? If so, we would like 3000 this time." We concur with Author Bates in that we are "glad to know that the article has proven so popular."

That's the amount of catalyst that Buell cyclones are collecting in fluid cat crackers every day... enough to build a pyramid the size of the Great Pyramid of Cheops. Operating experience has convinced refineries to rely on Buell Cyclone Systems for minimum catalyst loss. Buell systems for fluid bed processing include: fluid catalytic cracking units, hydroforming, coking, coal carbonization, iron ore reduction. To meet the most stringent air pollution codes refineries also prefer a combination system with Buell Electric Precipitators. Buell Engineering Company, Inc., Department 61-C, 123 William Street, New York 38, New York; Northern Blower Division, 6405 Barberton Avenue, Cleveland, Ohio. Cyclones • Electric Precipitators • Bag Collectors • Combination Systems • Classifiers • Fans

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From the editors...

Quick Look at HPI

'NO SALE' SAY SHELL AND BRITISH PETROLEUM, as companies scotch rumors they plan to sell interests in Anglo-Egyptian Oilfields, refining-producing affiliate in Egypt. Government slashed holdings of each from former 31% to 15.5% each, as last 400 big businesses in Egypt are nationalized. Companies were reimbursed for confiscated shares with UAR government bonds paying 4% interest. Some experts feel Shell-BP will eventually be forced out completely now that UAR owns 55% of AEO.

USED MOTOR OIL re-refining is going great guns in about 150 companies in U.S. They're gathering crankcase oil from filling stations, fleet cabs, trucking and bus firms, and railroads. Big issue: How does re-refined product stack up against virgin oils? Evidence gathered by Armour Research and others shows properly re-refined and fortified lube oil is "at least as good as original, if not better." Some railroads and military users say they resist oxidation better, lubricate more effectively and result in less consumption.

CARBON BLACK BOOM on in earnest overseas, where production is growing twice as fast as in U.S. The big market: Auto tires. On the bandwagon with new plants or expansions of old ones are Phillips Petroleum (Italy, India, South Africa), Continental Carbon (Holland and Brazil), Constock International Methane (Pakistan), Columbian Carbon (Brazil, Italy and Canada), United Carbon (Venezuela), Texas Butadiene & Chemical (Argentina) and Cabot (Argentina).

PETROCHEMICALS IN UNITED KINGDOM seem to be taking over organic chemicals industry. By 1962, petrochemical production in U.K. will exceed 3 billion pounds—65% of total organic production, predicts British Esso Petroleum spokesman A. W. Pearce. U.K. petrochemicals grew from 6% of total organic production in 1949 to 51% in 1951. They are expected to tack on additional 14% by end of 1962, for 65% total.

SIGNAL OIL SUES U.S. GOVERNMENT for $1 million over damages company says resulted from dredging done by Corps of Engineers in Houston Ship Channel 2 years ago. Signal says damage to $50-million, 110-acre refinery was caused when channel was dredged wider and deeper than necessary. Result: Some property has fallen in channel, while other land slopes toward waterway, endangering $1 million worth of equipment.

HELIUM PRICE INCREASE, from $19 to $35 per Mcf, announced by Bureau of Mines, to "help pay for government's helium conservation program." Hardest hit by upping of wholesale price will be government agencies, which are biggest users. Helium sold to private companies retails for $60 to $110 per Mcf.

PANNING THE PROCESS & PRODUCT SCENE you'll see Houdry up with halide-free catalyst working in Japanese reforming units. Catalyst can easily be regenerated in place...Polymer Corp. introducing Monsanto's new process for polymerizing caprolactam while casting polymer into large shapes, simultaneously. Result may be big nylon-6 molded shapes to compete with

brass casting and stainless steel...Alternating copolymers of ethylene and internal olefins being made at Italy's Instituto di Chimica Industriale del Polytechnico. They are linear and have high molecular weight.

Japan's Toyo Rayon eyeing production of gamma-radiated formaldehyde used in acetal resins. Company has process in pilot-plant stage, and commercial plant is projected for 1962...Allied Chemical to build West Coast plant using new Von Heyden-Chemiebau fixed-bed phthalic process. It employs vanadium pentoxide. Process features "high yield," variety of feedstocks.

'BLOW-BY' DEVICES will be standard equipment on all new automobiles, starting with 1964 models, or legislation will be proposed making device mandatory. So says Abraham Ribicoff, Secretary of Health, Education, and Welfare, in ultimatum to U.S. automobile manufacturers. Device traps unburned hydrocarbon vapors and recycles them through combustion chamber of engine.

METRIC SYSTEM FOR U.S. moves closer to reality as House Committee on Science and Astronautics approves bill authorizing National Bureau of Standards to make $500,000 study. Goal: To determine desirability of using metric method as U.S. standard of weights and measures. If Congress passes bill, NBS would have three years to make study.

ITALY EYES OVERSEAS prospects for HPI investments, as Montecatini plans to build in Mexico. Meanwhile, ENI, Italian-government-owned oil entity, agrees to build refining and petrochemical plants in India. Deal calls for $100 million in men, materials and machines.

FRENCH SYNTHETIC FIBER production comes under control of Rhone-Poulenc as company plans acquisition of Celtex and its half-interest in Rhodiaceta. R-P already has 50% interest in Rhodiaceta—so result of merger will mean control of all French polyesters, acetates and polamides—plus 90% of staple fiber, rayon and yarn capacity, and big piece of acrylic fiber output.

QUICK LOOK AROUND THE WORLD finds Petrobas, Brazilian oil entity, decentralizing into subsidiaries of a holding company. Separate firms will handle refining, petrochemicals, production, transportation...Cities Service merging with Columbian Carbon to "greater diversify interests"...Soviets seeking commercial radiation-hydrazine process. So is Aerojet-General Nucleonics, which has such a process but admits "inefficiencies" and has gone back for more data...Standard of New Jersey suing Oil Import Administration in Federal Court for "fair and equitable" distribution of import allowances...Meanwhile, Conoco braces for fight with Justice Department over monopoly charges in connection with company's purchase of Malco Refining, New Mexico.

House investigation of crude-oil import program begins next month or in November. Probe started with charge that some inland refiners were selling allocations to coastal refiners at $1 to $1.25 a barrel. The charge: Violation of law that foreign oil be exchanged at domestic crude rate...Analysis shows construction-industry demand for plastics on rise. Market hit 1.4 billion pounds in 1960 or 24% of total production.

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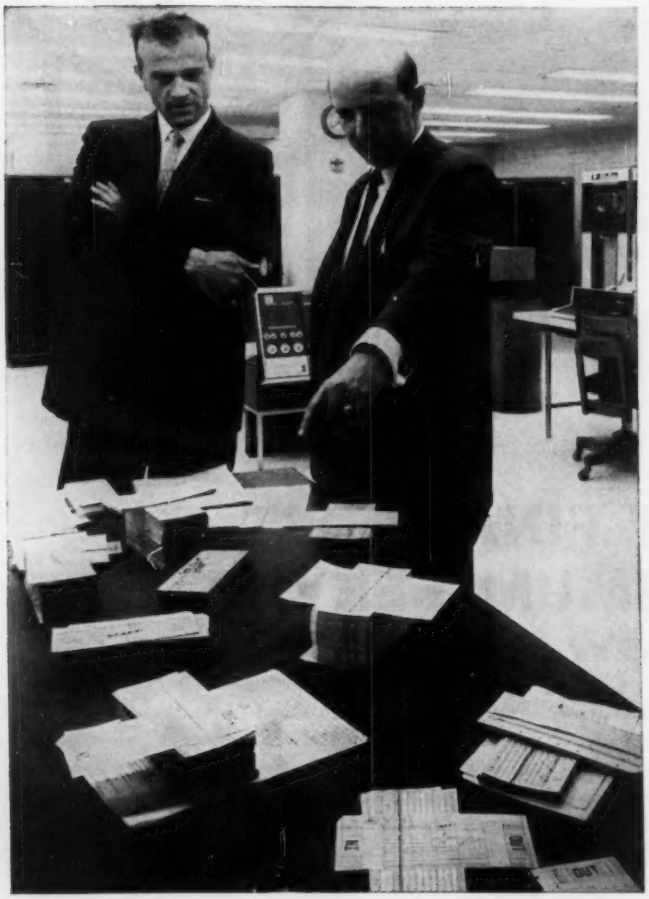
1 Many of the computer programs in Kellogg's extensive library have been developed jointly by process engineering and computer specialists.

More efficient engineering and sounder new plant investments will result from use of a new high-speed IBM 7070 computer installed at The M. W. Kellogg Company's headquarters in New York.

The new computer and improved programming techniques mark another major stride in Kellogg's continuing improvement of its engineering services. Its speed makes practical rigorous calculation and the evaluation of multiple solutions to difficult design problems—a vital step in achieving the most economic design.

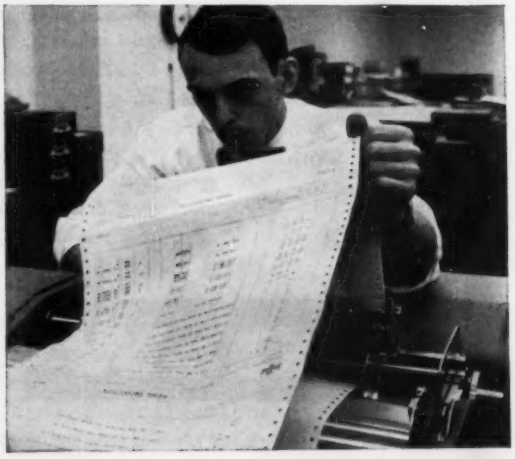
The computer's large capacity will enable Kellogg to develop new methods which can be applied to plant engineering problems. In addition, it will permit Kellogg to broaden its present activities in such areas as computer control, process dynamics, and systems engineering.

New engineering techniques and increased engineering efficiency are vital to the creation of optimum plants. If you are planning a new plant, Kellogg engineering services, more than ever, can help you achieve optimum plant design and a more economic investment.



2 Engineering data and computer commands, punched on cards and stored on magnetic tape, are read into the computer.

3 A printout provides engineering data ready for evaluation. Simplified methods permit ready use of computer for solving a wide range of process and mechanical design problems.



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Valuable Tool of the Trade

A MOST USEFUL TOOL in your day-to-day job as an engineer in the HPI too often gets little or no credit. Right off, we can tell you it is not your slide rule, nor any of the several handbooks, nor the desk calculator, nor manufacturers catalogs, nor technical magazines. Even The World Almanac or some other such commonplace aid isn't "it." Surely all of these help, but the tool we have in mind—the one we'd like to talk about is not included in such a prosaic accounting. Actually it would make very few lists because, as we say, it seldom wins any credit despite its almost daily and effective usefulness.

The mind, ability and memory of your associates is what we're talking about. The associate may share your office, or carry the title of group leader. Or he may be the guy down the hall or even the operator on a unit in the plant. Lucky, we say, is the engineer who has as co-workers a whole passel of capable men whom he can "borrow" from or lean on when the occasions arise.

How many times have you looked up and asked, "Joe, what were the results on that test you ran on Column A in Unit 2 last week"? Of course, it's all in a report you saw yesterday, initialed, and tossed into the out box, but your question needs that personal and interpretative answer which Joe can give quickly and directly. And Joe usually comes across with just what you wanted to know and you are soon off and running on the problem at hand. So this bit of data, sometimes seemingly quite trivial, tucked away in the corner of your associate's mind was just the key you needed to unlock the door to your problem. This picking of Joe's brain with questions deep and shallow can be just as important to you and your immediate problem as the huge electronic computer down the hall.

Two-Way Street. What really makes this work—and work it does for both you and Joe—is that it's a two-way street. You, of course, answer questions which Joe asks. And by so doing, both of you get your jobs done in better fashion and somewhat easier.

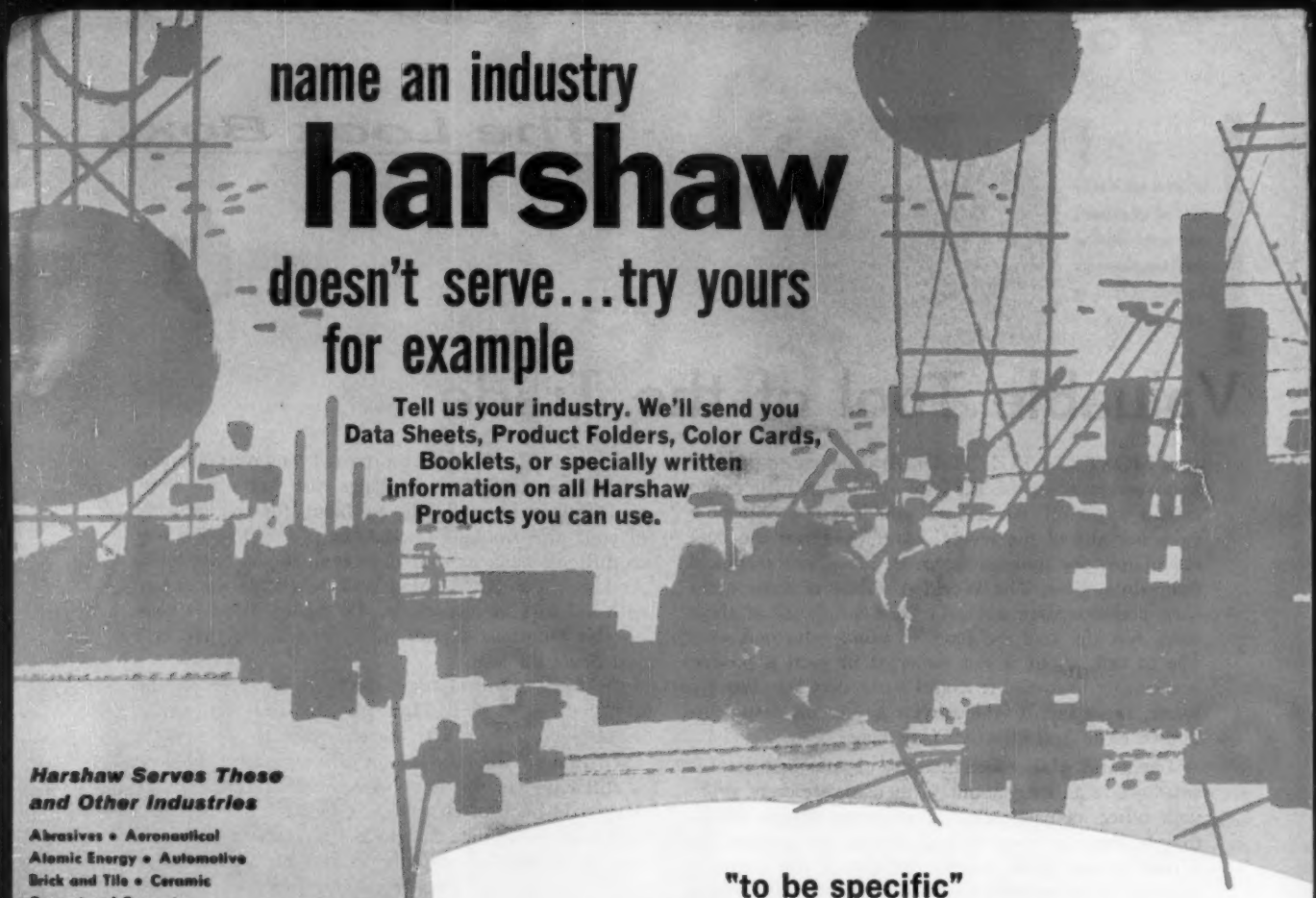
Then there's that character down the hall. He's a real long-haired scientist type with a head full of "indispensable" knowledge. It's common scuttlebutt that no normal person would clutter his brain with the sort of stuff he's got stashed away. Comes the day when you need a rate equation solved for that reaction that's been bugging your current plant design problem. Off you go to Ol' Scientist Sam. After some sideplay and the usual engineer-scientist "sharp" exchange of greetings, you lay open your soul and, incidentally the problem, for the scrutiny of your pipe-smoking chum. The problem which was so difficult back at your desk is duck soup for Sam. And soon you are headed back to the office happy as a kid at Christmas time. Ol' Sam is hard to beat on this long-haired stuff, and—aren't you glad he's just down the hall?

Or take friend George, the lead operator on the para-ballonium unit. That was the unit you "broke in on" when you first started with the company. Even though you now are an office engineer, George is still close as the telephone or the motor scooter parked in back of the office. Of course the problem may take some digesting to get it across to George, but he is usually sympathetic and completely clear with his answers. George doesn't hesitate to recall that Ed (now the plant manager) tried the same thing ten years ago and it didn't work out very well. But more than that, George will explain **why** it didn't work. This quickly adds to your knowledge and many times saves time and money. (This is also a two-way street, so don't ever let George down when he calls for information or has a problem he doesn't want the whole plant to know about.)

Then there's this angle:

Tooling the Boss. When was the last time you sat down with your boss, group leader or immediate supervisor for a discussion of the over-all department aims or goals? Been a long time hasn't it! But it's a good bet that you ask several questions of him every day, just like the ones you put to your office-mate Joe. These questions take many forms, such as general ones for direction or simple queries for advice and encouragement. Or they can be really detailed when you are trying to find out what results are expected from the current study you may be making. Chances are your boss has been around the plant longer than you and this historical knowledge and background can save lots of time and keep you from birddogging a setting hen. A question or two directed at appropriate times toward the boss can be a quick way of discovering many a blind alley before setting foot therein. Sometimes, too, it offers escape from reading an old report or two.

Such queries the boss welcomes and nearly 100 percent of the time you will get a useful answer. So surely it's a variation of exactly the same reliable tool



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which makes your job more pleasant and productive.

Using this tool—asking these questions—not only helps you with your current problem, but it serves other purposes too. Often as not when you ask Joe a question, this starts him to thinking. And many times these simple questions can lead to considerable brain searching. Thus your simple question might help Joe, your boss, Sam the scientist, or even George grow professionally.

Equally important as help with your immediate problem is the long lasting effect your question has on your relations with these people. This in reality is team work. You and Joe, Sam, George and Ed are all members of the team. And one of the best tools each of you can use is each other's knowledge.

Preachment For Frugality

IT IS THE WRITER'S GOOD FORTUNE to scan regularly publications issued by oil companies, small and large, domestic and foreign. On the whole, they are excellently done and contain much valuable and interesting information. We even get a kick out of the classified ads that some of them carry for benefit of employes, and on occasions have wished we were close enough to call the indicated phone number and snap up the proffered item.

However, what we started out to say is that of late there's been in these publications quite a wave of articles urging employes to economize in every way possible. By pictures and words the editors have tried to show how important economical measures are in these days of high costs that are squeezing profits. "If we can get our co-workers in the company to let some good old early American frugality govern all their company procedures and activities," the editors seem to be saying in chorus, "then we'll all be better off by the improvement effected in our fiscal report. The company will make more money because its products can be marketed cheaper and that, in turn, will result in an improved employe status."

There's good reasoning there, and we hope the ding-donging on this sensible topic will get the results our fellow editors and their management are hoping for.

In this connection, Esso Research and Engineering's biweekly, "The News" recently featured this rather pungent and pertinent item:

"How Big is Ten Dollars?

"Pretty big. It's the amount Jersey Standard must invest in order to make one additional dollar profit.

"But a dollar that can be saved in operating costs is extra profit without additional investment.

"Other oil companies are working hard to eliminate unnecessary costs. Jersey and its affiliates can't afford to be left behind in today's fiercely competitive oil markets.

"In this issue, The News begins a special series of articles to point up how employes can help to keep operating costs under control, and thus reduce the cost of research to affiliates and Jersey."

The moral of all this plethora of words, you doubtless have already grasped. If actually—those among you who direct tens or scores or hundreds of employes—if you could just get across with them the necessity of tighter operation, sensible and frugal practices and more frugality, then the industry's entire economy, not to mention the nation's, would be considerably improved.

Hydrocarbon Hysteria

ONE OF THE so-called petroleum industry problems (which the REFINER has felt was no problem at all) has turned out to be just that—*no problem*. What are we talking about? Why the dreaded compact car, of course! That's the critter, you recall, that was to be the David who could wreck the HPI Goliath—the gasoline market.

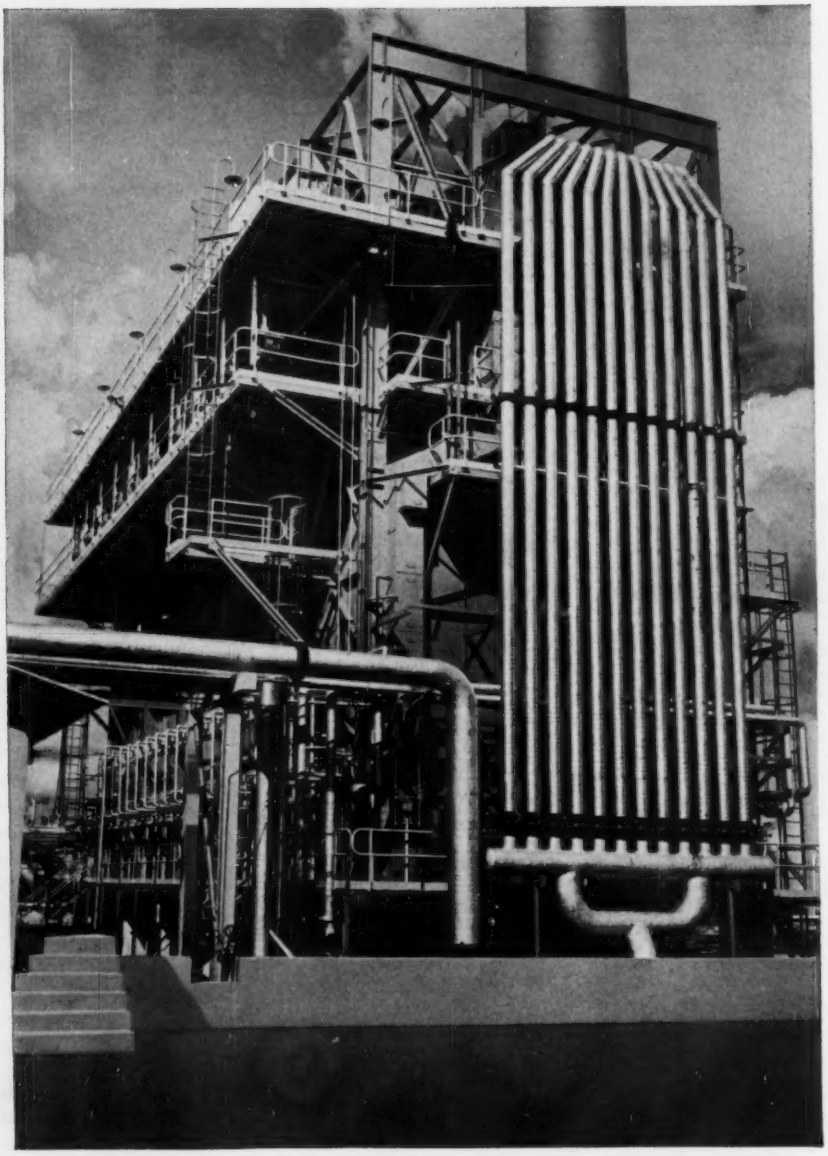
In May 1960 we published the editorial "Why Stomp Out Small Cars?" (which might better have been called "Petroleum People Push Proverbial Panic Button"). We tried to sooth the refiner's shattered nerves with the counsel that the little "doodle bug" compact's *threat* to the market existed only in the minds of some loud spoken folks plagued with a malady well known to petroleum people. It's called "hydrocarbon hysteria." Many in the HPI have had a dose of it, touched off by fuel cells, atomic energy, turbines, and even that "monster," *coal*.

Now it turns out that the little fuel-thrifty demons which were supposed to ruin the gasoline market are on their way out. They've moved over for a new critter—the "middle sized" compact, which is smaller than standard, and bigger than small. (What will Detroit come up with next?). But even if the bigger compact doesn't replace Corvairs, Falcons and Valients there is no reason for refiners to work up a lather and start looking for a job in the shoe industry.

Fact is, the compact hasn't lived up to the expectations of a good many drivers, including the "fleet" operators. A new study by a leading fleet-leasing firm, Peterson, Howell & Heather, Baltimore, studied the compact for itself and its customers.

Here's what they found on operating costs: Standard vehicles (Chevrolet, Ford, Plymouth) 7.63 cents a mile; Corvair, 7.18; Falcon, 6.73; and Valient, 7.32.

Conclusion: It costs about as much to drive a compact. Detroit market analysts apparently feel purchase price is no big factor—hence, the more costly middle compact. Moral: Don't count your compacts before they're hatched. This is not a vote for complacency—just a reminder that we should take a long, objective look at petroleum "problems" before jumping to conclusions.



Experience this big goes into all of our smaller heaters

What is the biggest thing about this heater? Not physical size or Btu absorbed, but experience! And the same high order of skill that made this unusual heater possible goes into every FW heater regardless of size . . . field-erected or shop-assembled. With each you may expect . . . precise correlation of burner and furnace design . . . the most appropriate selection of materials . . . and careful attention to detail.

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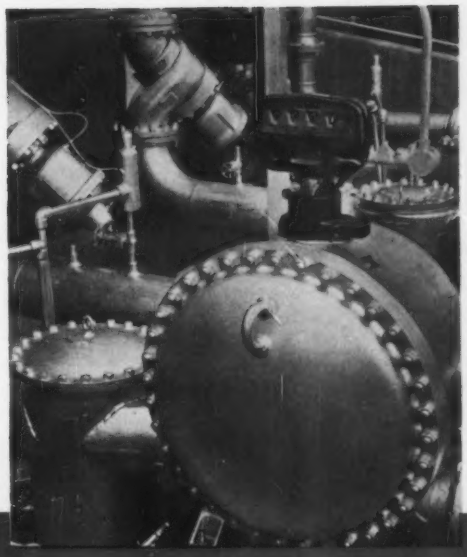

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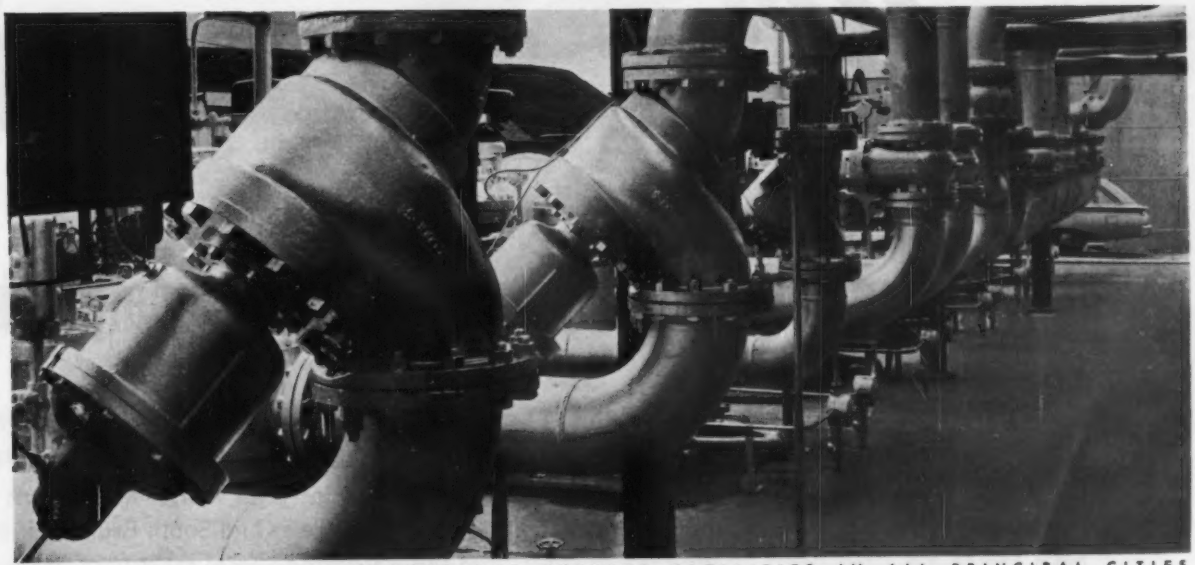
Photo shows interesting new blending installation with a battery of Brodie Series 500 Control Valves at Standard Oil Company of California Richmond (Calif.) refinery.



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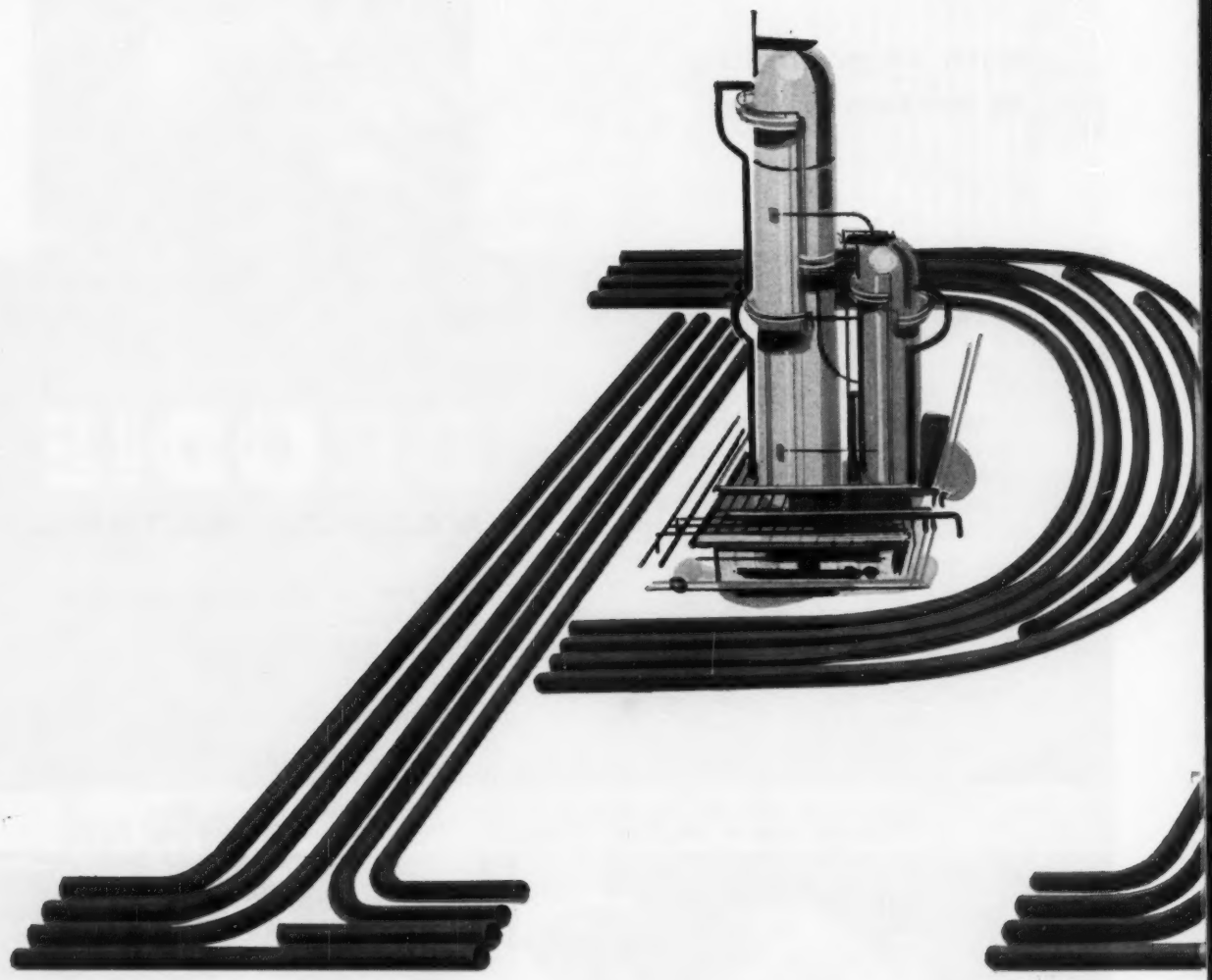

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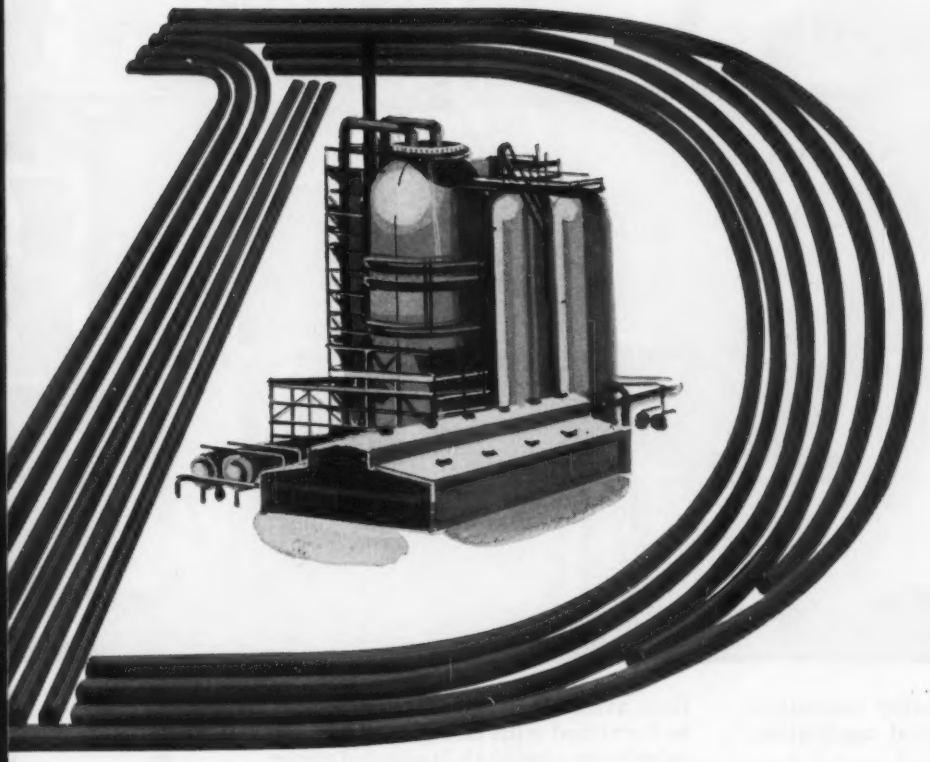

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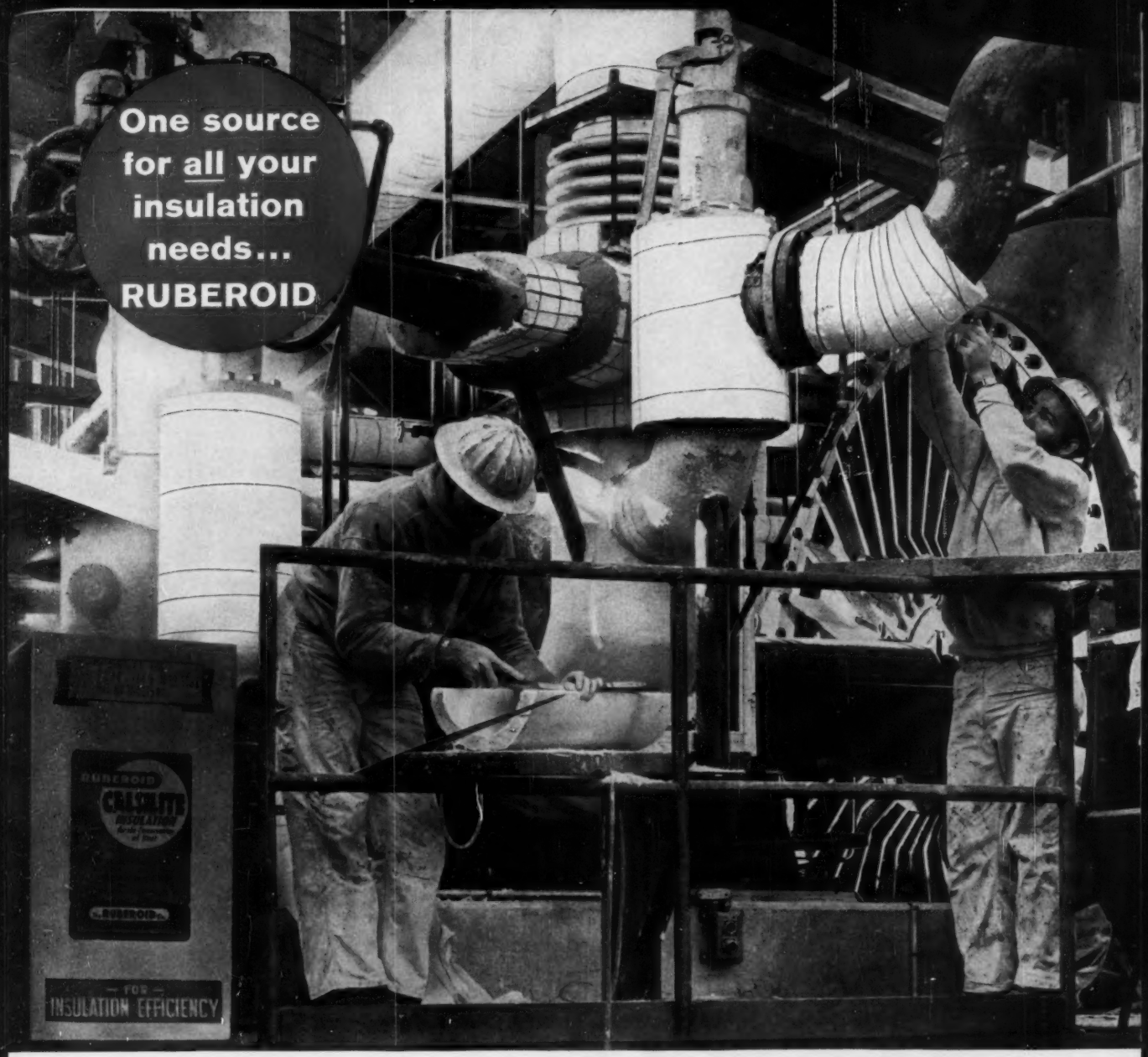

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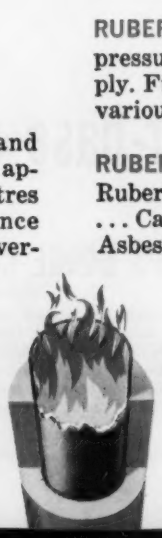

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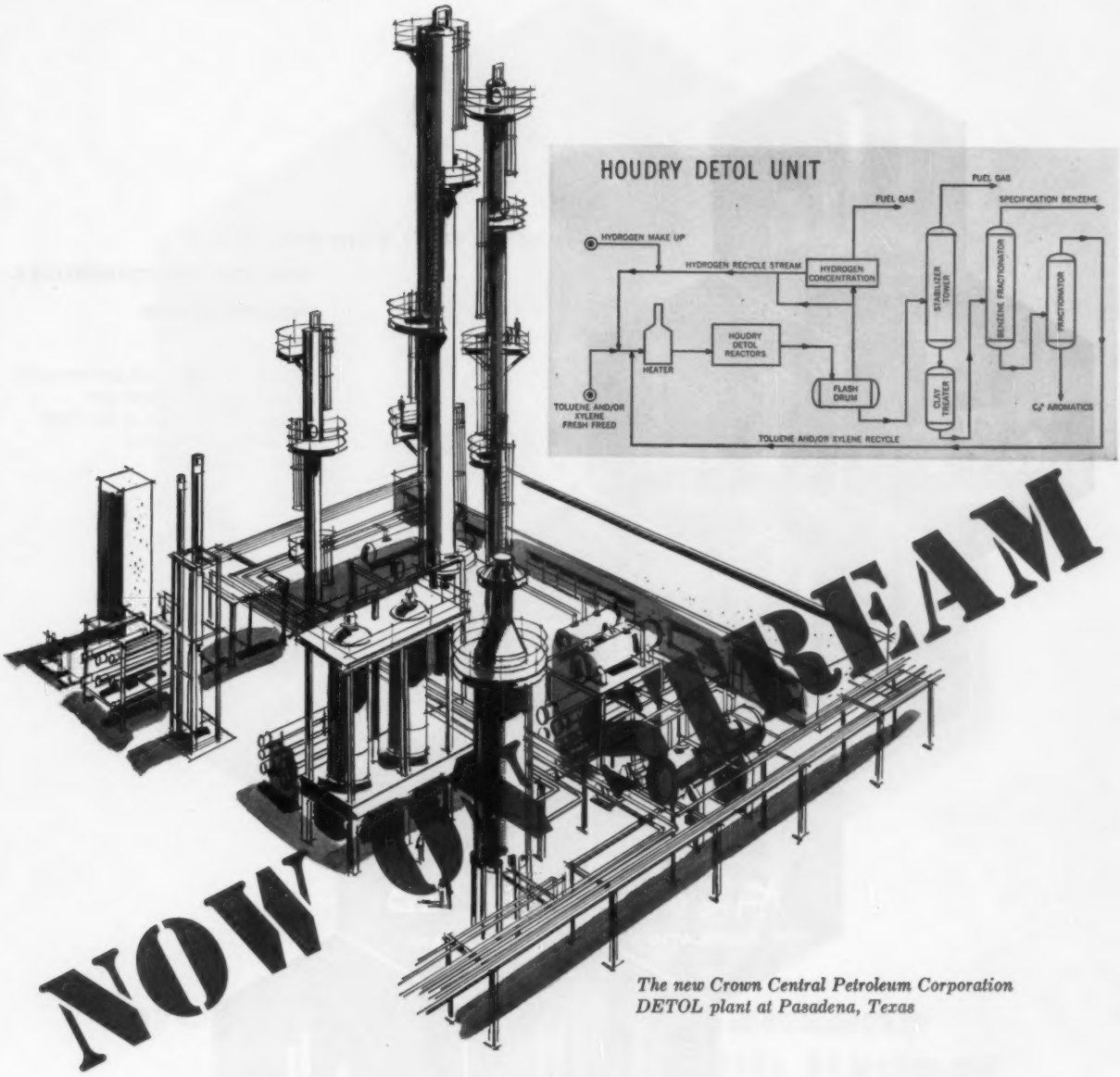

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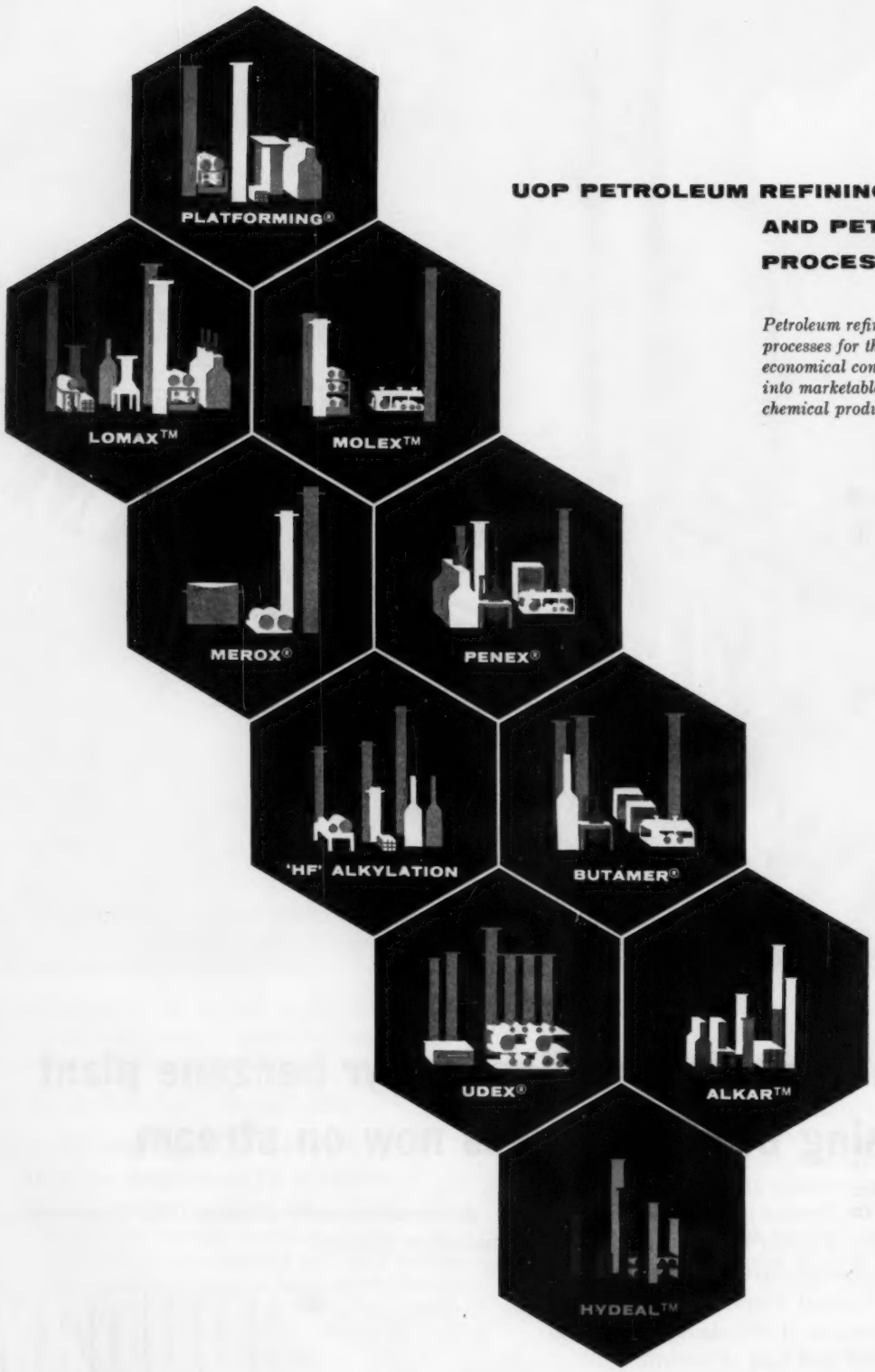

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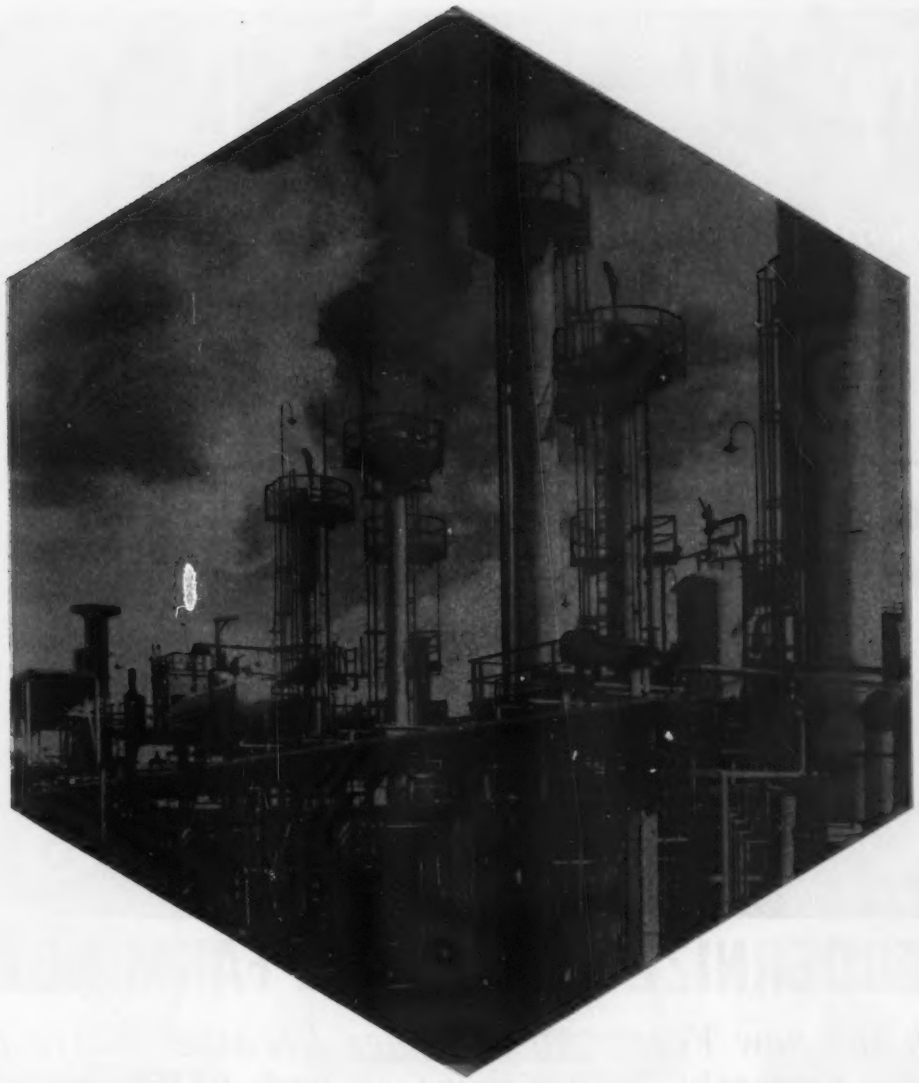

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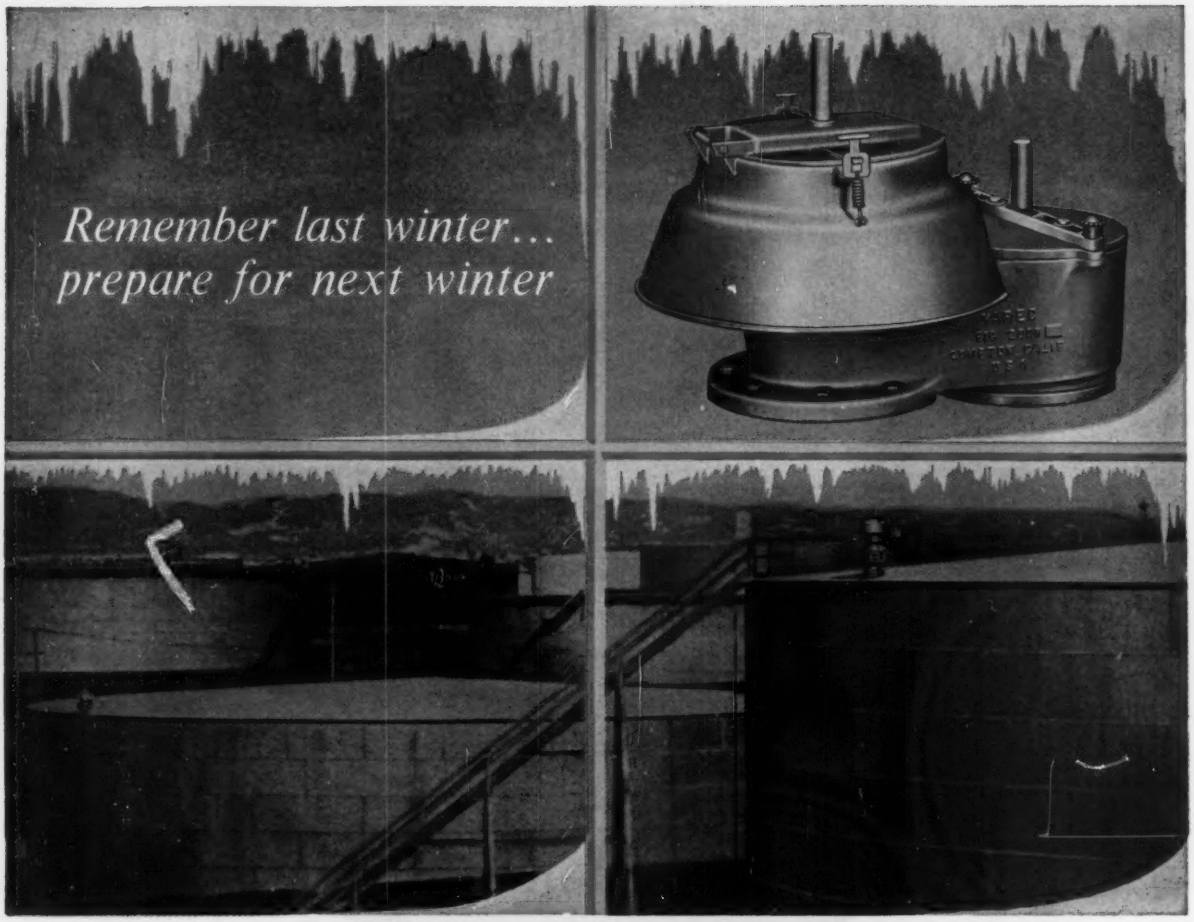

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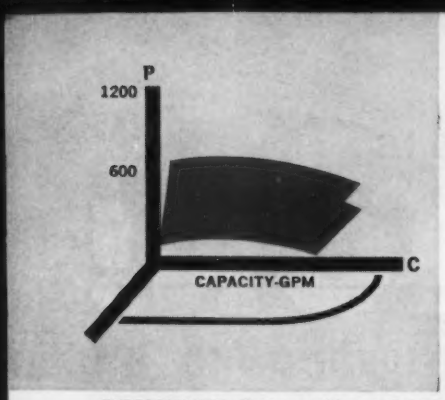

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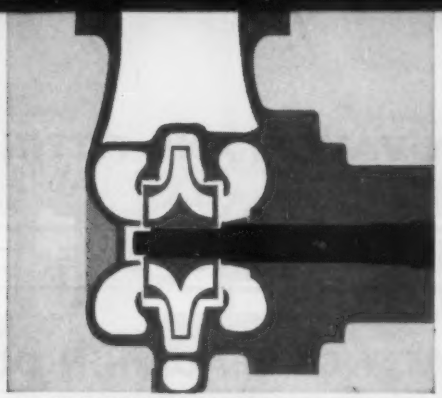
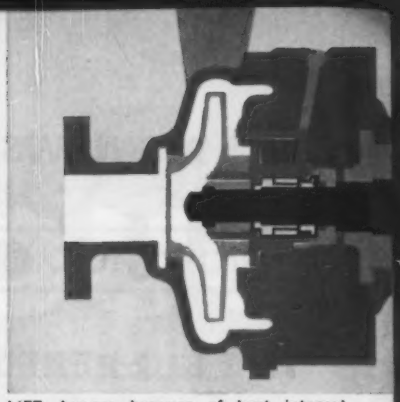
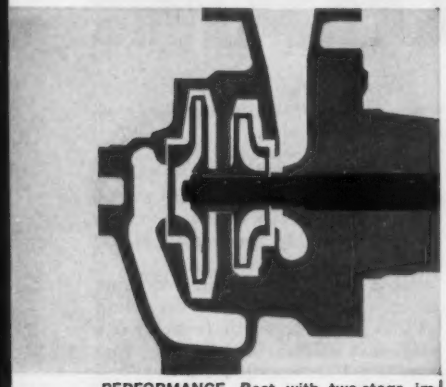


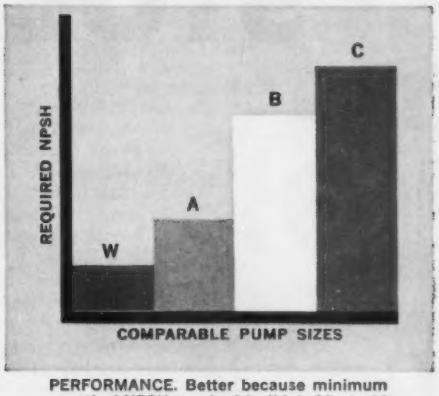
PERFORMANCE. Best with balanced double suction impellers for higher capacities.



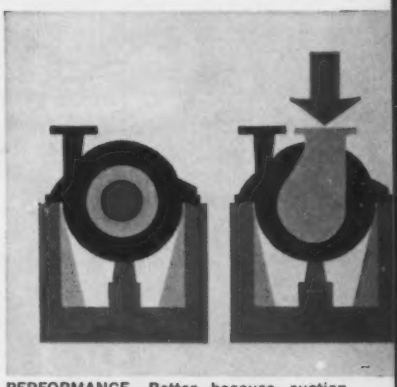
LIFE. Longer because of best internal liquid flow arrangement for flushing seal.



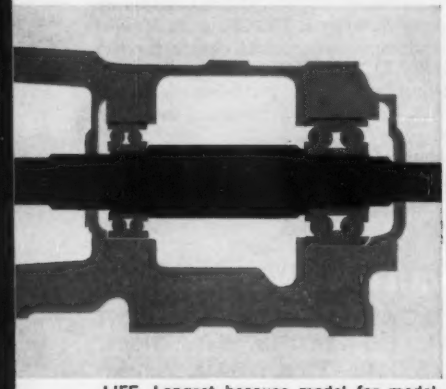
PERFORMANCE. Best with two-stage impeller design handling the higher heads.



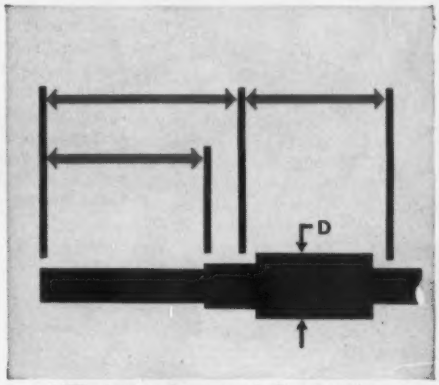
PERFORMANCE. Better because minimum practical NPSH required (validated by test.)



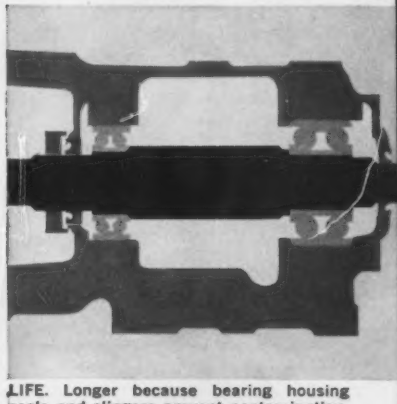
PERFORMANCE. Better because suction position varied to fit your pump installation.



LIFE. Longest because model for model, no heavier shaft bearings are available.



LIFE. Longer because shaft proportions are heavier, second to none. Analyze them!



LIFE. Longer because bearing housing seals and slingers prevent contamination.

For process work...

PUMP WITH EXCLUSIVE FEATURE PACKAGE

These are some—not all—of the important features of the Worthington HN process pump line. These features form an exclusive group that we know packs more value into the price than any comparable process pump.

One competitive pump may have one or more of these features. Another may have others. But no other pump line offers them all.

Judge this line for performance—working temperatures and pressures are unsurpassed. Judge this line for long life—its construction features add up to the most dependable design and its corrosion allowances are the best in any pressure range. Judge this line for versatility—its materials and construction variations are economical for use throughout your plant.

Frankly, we'd like you to examine in complete detail the exclusive feature package that we offer in this HN process pump line. Its current design and quality control techniques are dictated specifically by our long experience in the process industries.

Better yet, let us quote this line so you can see its complete value in a competitive light. Please contact your nearest Worthington District Office, or write Worthington Corporation, Dept. 21-8, Harrison, N. J. In Canada, Worthington (Canada) Ltd., Brantford, Ontario.

WORTHINGTON

PRODUCTS THAT WORK FOR YOUR PROFIT

THE BIG NEWS IN VALVES AND FITTINGS IS

DUCTILE IRON!

THE BIG PERFORMANCE LEADER IN DUCTILE IRON IS

STOCKHAM!

Unbeatable performance . . . substantial savings on initial cost . . . lower maintenance costs . . .

These are the three main reasons why engineers throughout the country are now specifying *Stockham* Ductile Iron Valves and Fittings as replacements for steel in many services.

For Stockham's leadership invariably produces the *best* of the *newest*.

Rigid metallurgical control involving continuous tests and analyses assures you superior ductility (far exceeding ASTM specifications) . . . excellent strength (comparable to carbon steel) . . . corrosion resistance (equal to cast iron and 5 to 7 times greater than steel) . . . wear resistance . . . and impact resistance.

These metallurgical superiorities . . . combined with the performance-proven advantages of Stockham's superior design features . . . make Stockham Ductile Iron Valves and Fittings the best and most economical choice for the following RECOMMENDED SERVICES:

—Underground distribution lines . . . brine solutions . . . brackish water . . . ammonia . . . solvent recovery services . . . acids.

—Efficient replacement of cast steel valves in most petrochemical and hydro-carbon processing installations for services up to 650°F.

AVAILABLE NOW!

STOCKHAM DUCTILE IRON VALVES—150 lb. class Globe, N R S Gate, O S & Y Gate, Venturi Pattern Gate.

DUCTILE IRON FITTINGS—300 lb. screwed and 150 lb. class flanged fitting.

See your local Stockham Distributor or write now for new 12-page Ductile Iron Valve and Fitting Catalog giving complete details.

AVAILABLE THROUGH YOUR LOCAL STOCKHAM DISTRIBUTOR

Bronze, Cast Iron, Ductile Iron, Cast and Forged Steel Valves — Wedgeplug Non-Lubricated Plug Valves — Cast Iron, Malleable and Ductile Iron Pipe Fittings.

STOCKHAM
VALVES *and* FITTINGS

General Offices and Plant
4001 10th Avenue, North • Birmingham, Alabama

HOKE Flow Sheet 7

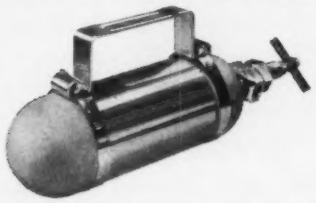
HOKE REPORTS ON FLUID CONTROL

PRESSURE BY THE POUND... no matter how thin you slice it!

Do You Have A Bomb In Your Lab?

In the process industry, sampling cylinders are occasionally referred to as bombs. In recent months, this misnomer has been, unhappily, pretty close to the truth. Some military surplus, low carbon steel, two-piece cylinders have found their way into industry and have been used beyond their rather limited capabilities. Unfortunately, several serious accidents have spotlighted this use as a very real safety problem.

Since sampling is such a serious business, we have perfected, for maximum safety, a seamless, one-piece cylinder. This unabashed declaration of excellence has sound

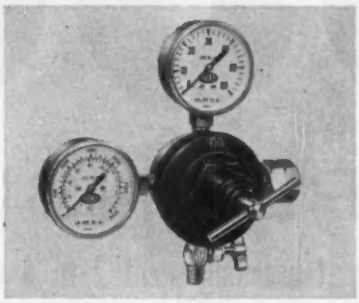


basis in fact – the entire cylinder is formed from a single piece of seamless type 304 stainless steel tube. To quell the qualms of process men, sample contamination is practically nonexistent, and the cylinder resists destruction from most corrosives.

As a further safety guarantee, all standard sampling cylinders are fabricated to meet ICC and other safety regulations. Standard cylinders are available at pressures to 1800 psi (10 ml. to 1 gallon), but higher pressure cylinders can be had on special order.

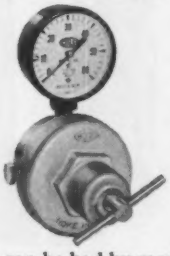
If you'd like additional information on Hoke cylinders, plus a detailed paper on the various methods of collecting samples from process lines, drop us a line. We'll also include details on special cylinder valves, outage tubes and other cylinder accessories.

One trouble with doing something better is that it's hard to stop. This time, we've come up with a new line of pressure regulators. We made them for the technically oriented who have developed high standards and for the penurious purchaser who wants something for (almost) nothing.



One, tagged as the 680 Series, is a highly stable single stage regulator with something for just about everyone. The core of this regulator is its control accuracy of 2% at flows to 2000 SCFH. Two models are available. One delivers 0 to 40 psi and the other 0 to 140 psi and both can handle inlet pressures up to 3000 psi. Use them on any gas compatible with 2024-T4 aluminum alloy, neoprene, polyurethane and Buna-N.

If what we've said sounds good so far, but still won't solve your problems, read on.



We've built a regulator specially for corrosive gases and atmospheres. Available in either all monel or all stainless steel construction, we call it the 640 Series. Spec sheets on this can be had by marking an "X" below.

If you "X" the next box, you'll get a package of useful information on a special regulator that will handle delivery pressures up to 4500 psi with very high control accuracy. This is a 2 stage spring and dome loaded regulator and we claim that a 50% change in inlet pressure will not change the delivery pressure more than 2%. Operation is simplicity itself. For no particular reason, we call this the 920 Series.

Skeptics should send for all of this information.

'61 PRODUCT PARADE

You'd be surprised at some of the screwball ways our valves have been used (to decided advantage, of course). Hoke distributors are armed to their maxillary third molars with this method madness and will redesign your systems with new Hoke products at the drop of a postcard. Check the PRODUCT PARADE Box.

Hoke's Performance Guarantee—*Every Valve Leak-Tested!*

HOKE INCORPORATED
167 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ 680 Series Regulator
- ☐ 640 Series Regulator
- ☐ 920 Series Regulator
- ☐ '61 Product Parade
- ☐ Sampling Cylinders
- ☐ Complete Catalog GC561

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

SEE OUR CATALOG IN SWEETS PRODUCT DESIGN FILE

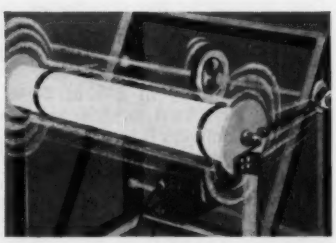
For more data on advertised products, use cards, last page.

TOUGH

NEW PIPE INSULATION

...deflection at breaking point 2 to 4 times that of ordinary insulation

You can almost forget about handling breakage with remarkable new "K&M" Zebra. As proved in tests by K&M and independent testing laboratories, Zebra won't crack or warp from shock or heat. It withstands intense vibration without cracking or abrading.



Zebra is made in half sections even for the larger pipe sizes... for faster application with fewer joints. Despite its rugged, full body, it's relatively lightweight... easy to cut and fabricate. It's a low, medium and high-temperature multi-layer sectional-type thermal insulation. And it meets your requirements for density, conductivity, modulus of rupture, and resistance to soaking heat. Write today for more information and a free sample of new "K&M" Zebra. It's tough, economical, fast to apply. That's Zebra... by K&M! Keasbey & Mattison Company, Ambler, Pa. Dept. I-291

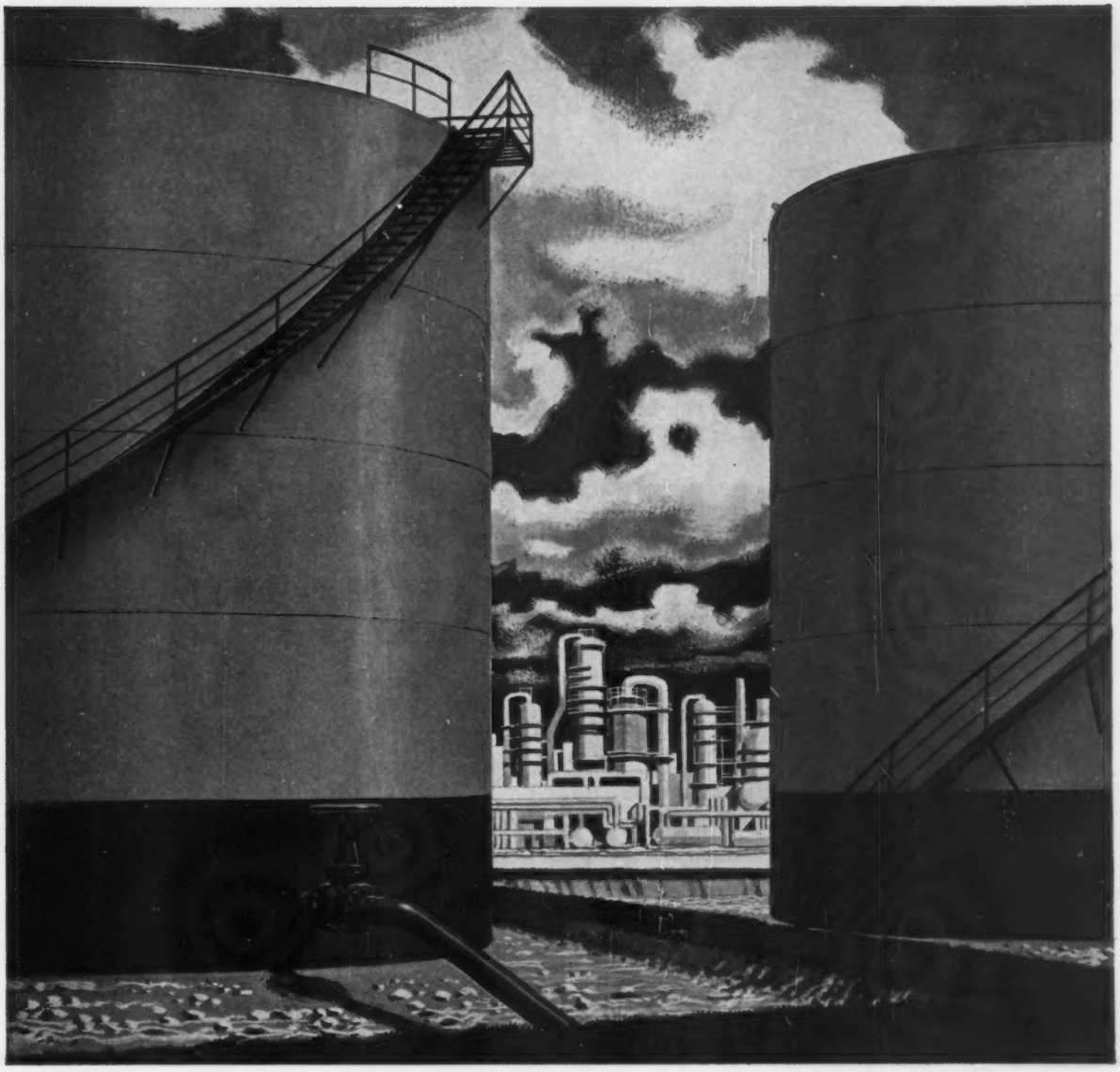
In Canada: Atlas Asbestos Company Ltd., 5600 Hochelaga Street, Montreal 5, Canada.

• for temperatures of 200°F to 1200°F • smooth surface won't irritate or cut skin • made of calcium silicate-asbestos fiber bonded felts • can be re-used . . . dismantled and re-applied • practically dust-free • available in a wide range of sizes and thicknesses.

ZEBRA

K·M
BEST IN ASBESTOS

Keasbey & Mattison at Ambler



Durable tank paints that keep uniform color

That's what you get when you specify paints made with M50® Basic Lead Silico Chromate pigment.

Paints made with *M50*® Basic Lead Silico Chromate pigment not only protect metal, but have remarkable resistance to chalking and fading in harsh industrial atmospheres that threaten color uniformity. They provide "Defense-in-Depth" against corrosion.

And Basic Lead Silico Chromate can be tinted in an unusually wide range of colors—bright hues, soft pastels and other combinations—that can convert your tanks and installations into attractive outdoor "advertisements" for you.

Next time you buy paint for decorative metal protection, specify paints made with *M50* Basic Lead Silico Chromate—the pigment that offers primer-protection in every coat, plus durability, uniform resistance to weathering and wide color range.

Typical M50 pigment paint | Typical standard specification paint

Test panels after being exposed for 18 months in an industrial atmosphere.

M50 an **oncor** *Pigment... A Development of* **National Lead Company**

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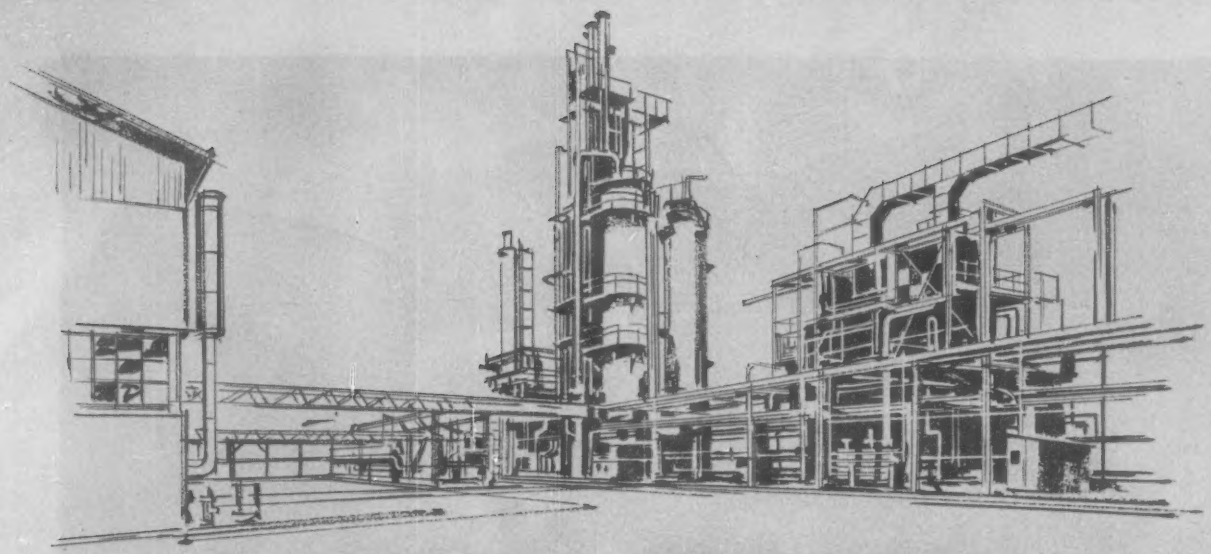


ISOLATE PIPE LINES ...ADD NEW EQUIPMENT

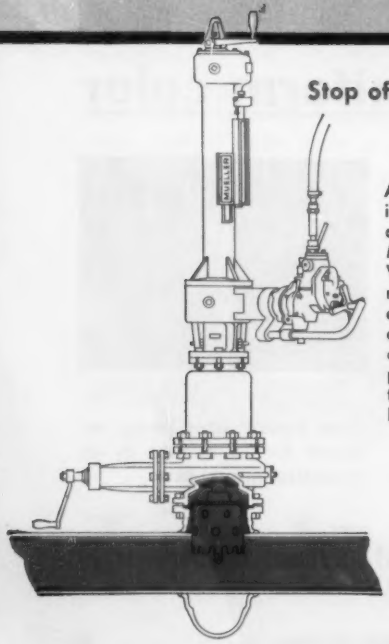
under pressure!

You can make repairs... isolate lines that need replacing... tie-in new piping... install new equipment—without interrupting flow or loss of production. There is no blowing of gas or fluids as you make permanent connections under full pressure and in complete safety.

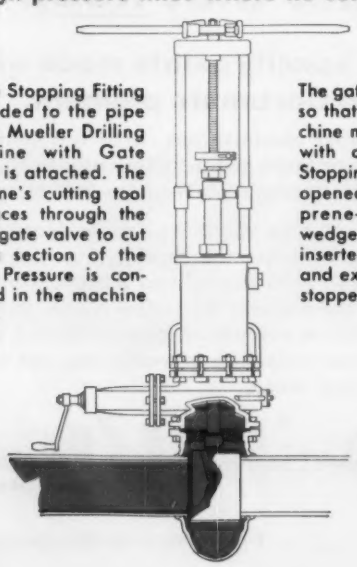
Mueller® No-Blo® methods and products enable you to work on piping systems whenever needed. A complete line of Mueller fittings, valves and equipment provides an answer to most every problem of working on lines under pressure.

Basic steps of Mueller No-Blo Methods are shown briefly in these illustrations...

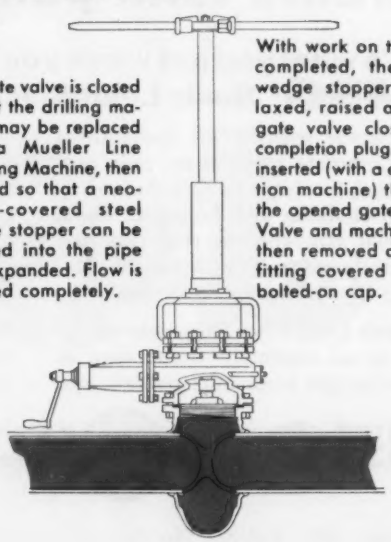
Stop off high pressure lines where no control valves exist—



A Line Stopping Fitting is welded to the pipe and a Mueller Drilling Machine with Gate Valve is attached. The machine's cutting tool advances through the open gate valve to cut out a section of the pipe. Pressure is contained in the machine body.



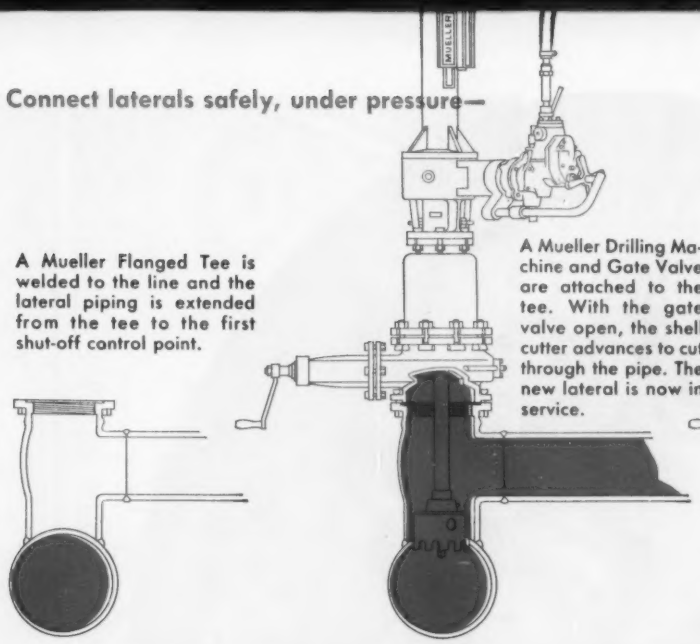
The gate valve is closed so that the drilling machine may be replaced with a Mueller Line Stopping Machine, then opened so that a neoprene-covered steel wedge stopper can be inserted into the pipe and expanded. Flow is stopped completely.



With work on the line completed, the steel wedge stopper is relaxed, raised and the gate valve closed. A completion plug is then inserted (with a completion machine) through the opened gate valve. Valve and machine are then removed and the fitting covered with a bolted-on cap.

Connect laterals safely, under pressure—

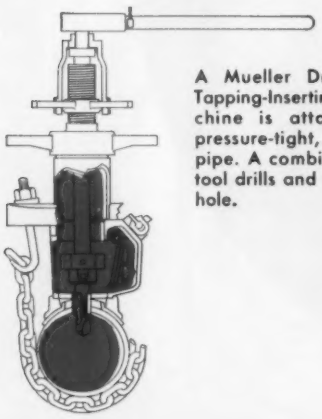
A Mueller Flanged Tee is welded to the line and the lateral piping is extended from the tee to the first shut-off control point.



A Mueller Drilling Machine and Gate Valve are attached to the tee. With the gate valve open, the shell cutter advances to cut through the pipe. The new lateral is now in service.

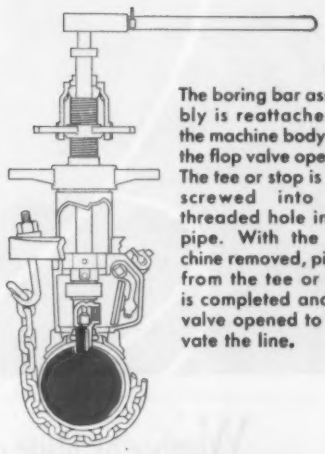
The cutter is withdrawn, the gate valve closed and the drilling machine replaced with a completion machine. With gate valve opened, a completion plug is inserted and screwed into place, permitting removal of the gate valve and machine. The plug and tee are capped completing the connection.

Tap a hot line without welding—



A Mueller Drilling-Tapping-Inserting Machine is attached, pressure-tight, to the pipe. A combination tool drills and taps a hole.

The tool is retracted and a flop valve in the body is closed to contain the pressure. The tool can then be removed and a valve tee or stop in closed position is attached to the boring bar.



The boring bar assembly is reattached to the machine body and the flop valve opened. The tee or stop is then screwed into the threaded hole in the pipe. With the machine removed, piping from the tee or stop is completed and the valve opened to activate the line.

Mueller No-Blo products to save time and money:

Large Drilling Machines—Cuts to 12". Working pressure to 500 p.s.i. Working temperatures to 500° F. Power or hand-operated.

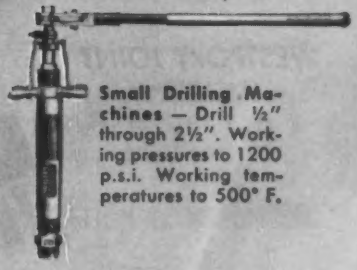
Completion Machines — For fittings through 12". Working pressures to 500 p.s.i. Working temperatures to 250° F.

Line Stopper Units—Stop-off ¾" through 12" lines. Working pressures to 500 p.s.i. Working temperatures to 250° F.

Flanged Tees—Sizes from 3" through 8". Pressure ratings to 1200 p.s.i. Temperature ratings to 500° F.

Line Stopper Fittings — Sizes from ¾" through 12". Welding or mechanical joints. For steel, thin-wall steel or cast-iron pipe. Pressure ratings to 1200 p.s.i.

Valve Tees — Sizes through 2". Welding or threaded inlet and/or outlet. Pressure ratings to 1200 p.s.i. (Machine inserted Valve Tee — 250 p.s.i.)



Small Drilling Machines — Drill ½" through 2½". Working pressures to 1200 p.s.i. Working temperatures to 500° F.

NO-BLO®

MUELLER CO. Since 1857 SERVING the Water and Gas Industries QUALITY

MUELLER CO.

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6385

Whether by blade or electric shaver, you know very well that it takes experience to get a perfect shave. And, that is no less true of fabricating and erecting critical piping. You'll stand to reap more satisfaction from beginning to end—if you delegate your high-temperature, high-pressure piping *directly* to experienced specialists. Next time ... ask us in!

W. K. MITCHELL & CO., INC.

Philadelphia 46, Pa.

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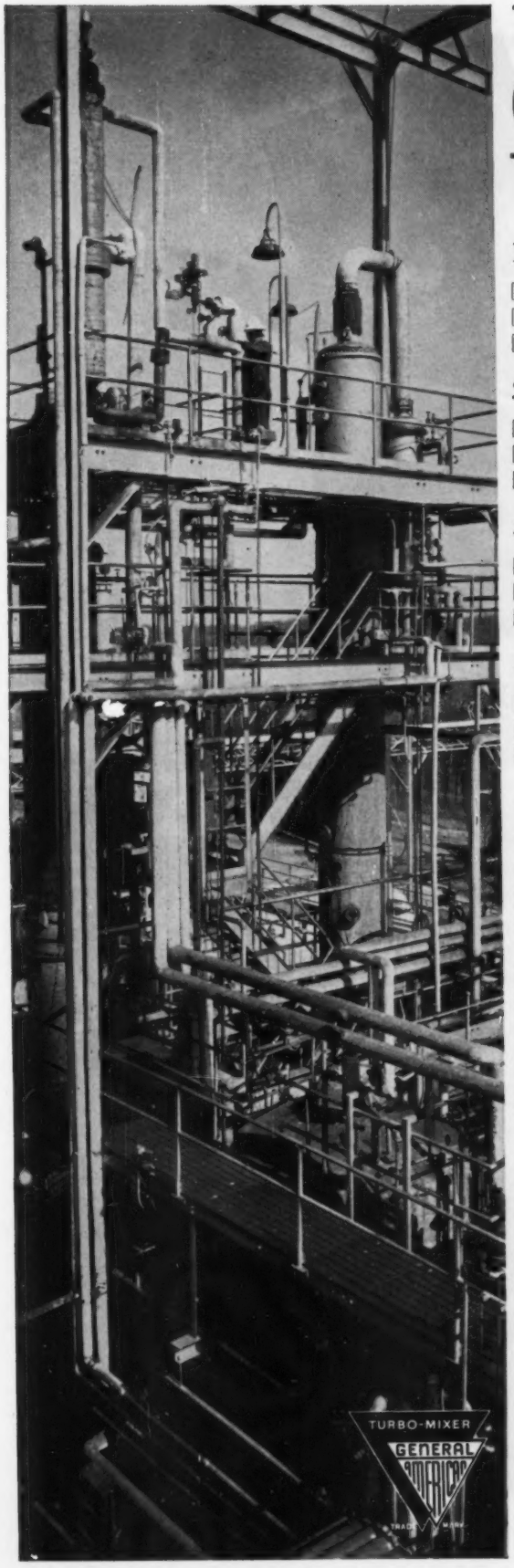
MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS



TRY THIS SIMPLE QUIZ ABOUT THE **RDC** COLUMN

1. *R.D.C. stands for*

☐ a) Rapid Dispersion Column
☐ b) Recycle Displacement Column
☐ c) Rotating Disc Contactor

2. *RDC Columns are made by*

☐ a) 6 different manufacturers
☐ b) by one manufacturer
☐ c) by 10 manufacturers

3. *The RDC column has been used for*

☐ a) Separation of Hafnium from Zirconium
☐ b) Caustic extraction of acids from organics
☐ c) Caffein and vanillin extraction

4. *The RDC column can be used for*

☐ a) liquid-liquid extraction
☐ b) liquid-solid extraction
☐ c) liquid-slurry extraction

5. *The RDC column has which of these advantages*

☐ a) High volumetric efficiency
☐ b) No interstage coalescing or external settling
☐ c) Low power requirements

Answers

1. (C) Rotating Disc Contactor

2. (B) RDC columns are made only by the Turbo-Mixer Division of General American Transportation Corporation for all industries except petroleum. Manufacture is licensed under Shell Development Corporation patents.

3. (A), (B) and (C). For a complete list of typical systems in service, contact General American.

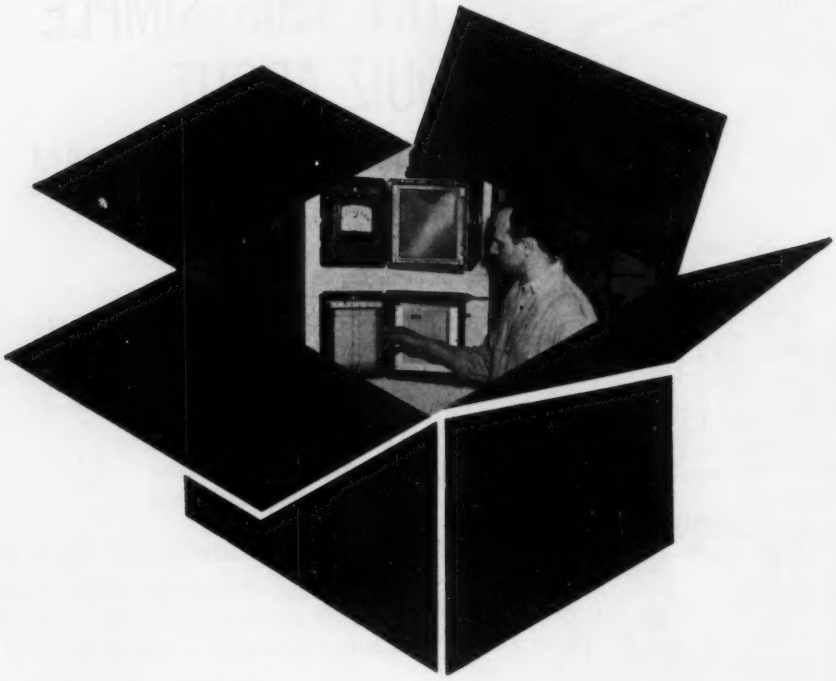
4. (A), (B) and (C) again. The RDC column is one of the most versatile tools available for extraction processing.

5. (We did it again—all three are correct).

If you'd like more information on the RDC column and the many advantages it offers, send for Bulletin T-1159. You'll find it pays to plan with General American.

Process Equipment Division—Turbo-Mixers
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South LaSalle Street • Chicago 3, Illinois
Offices in principal cities

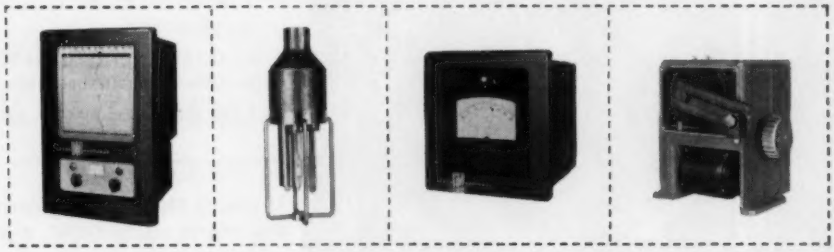
For more data on advertised products, use cards, last page.



Why settle for less than a complete pH control package...

. . . when you can get *all* the needed process-proved equipment — from electrodes to valve drive units — designed and manufactured by L&N? Whether you need electric, electropneumatic or pneumatic control, we take *complete responsibility* for the successful operation of your equipment package.

And to assure you the correct instrumentation, our staff of experienced engineers checks all the factors involved in your particular control problem . . . factors such as agitation, flow rate and its variations, changes in acidity, retention, detection lag, selection of the control point and the rangeability of feeding devices. By analyzing these factors, our engineers determine the type of control applicable to your particular problem . . . whether it involves waste treatment, cooling tower water, pH of production agents, or other.



If you want complete pH control . . . *with a single source of responsibility* . . . it will pay you to call your nearest L&N Field Office, or write 4923 Stenton Ave., Philadelphia 44, Pa.

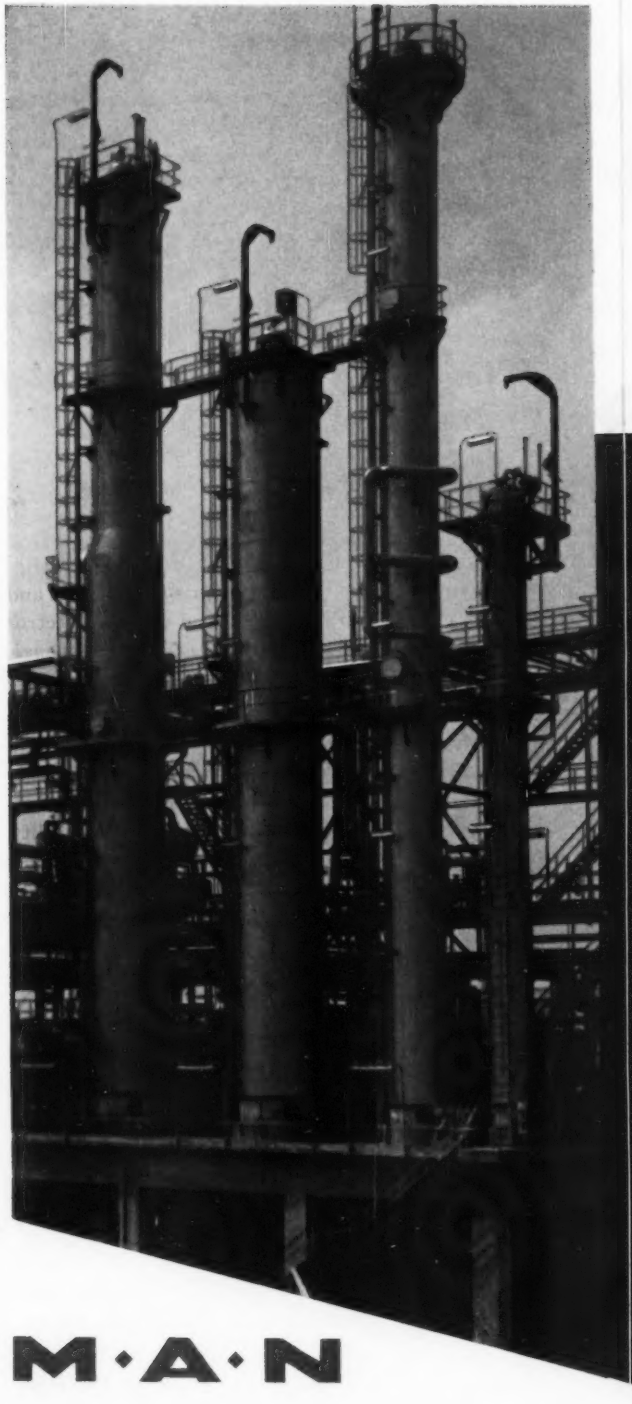
LEEDS & NORTHRUP *Pioneers in Precision*

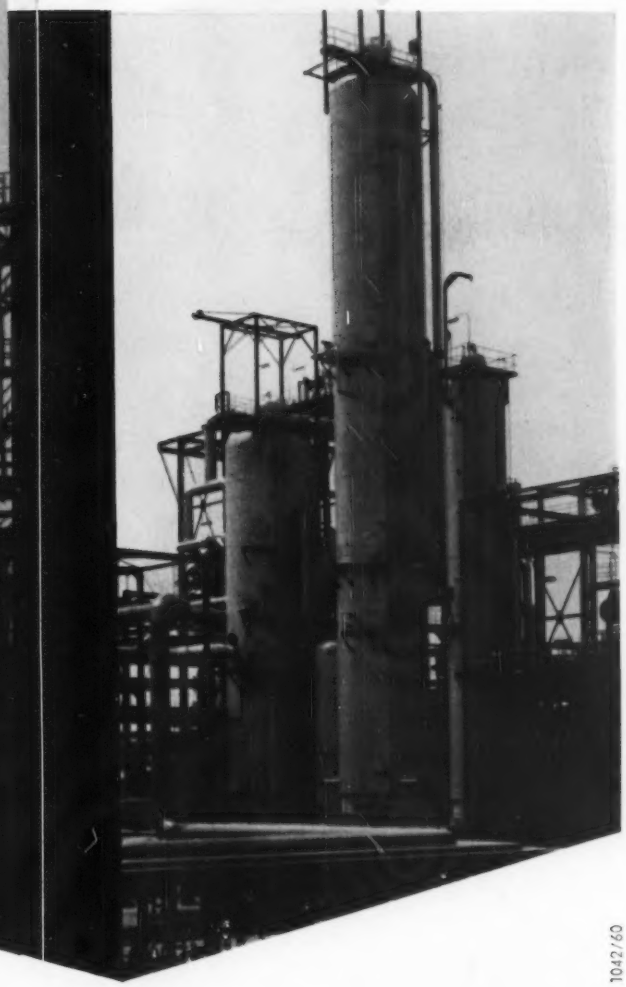
In 1959 we supplied to and erected on behalf of the Deutsche Shell AG. for their Godorf Refinery the

Distillation Unit
Gas Recovery Unit
Absorber Unit
Heat Exchangers and
Structural Steelwork.

Design and engineering work was carried out by the Bataafsche Petroleum Maatschappij N.V. and the Comprimo N.V., The Hague, whereas matters relating to purchase and inspection were attended to by Edeleanu GmbH., Frankfurt.

Our range of products also includes spherical tanks, pressure vessels and accessories for nuclear power stations, air coolers and regenerative heaters.





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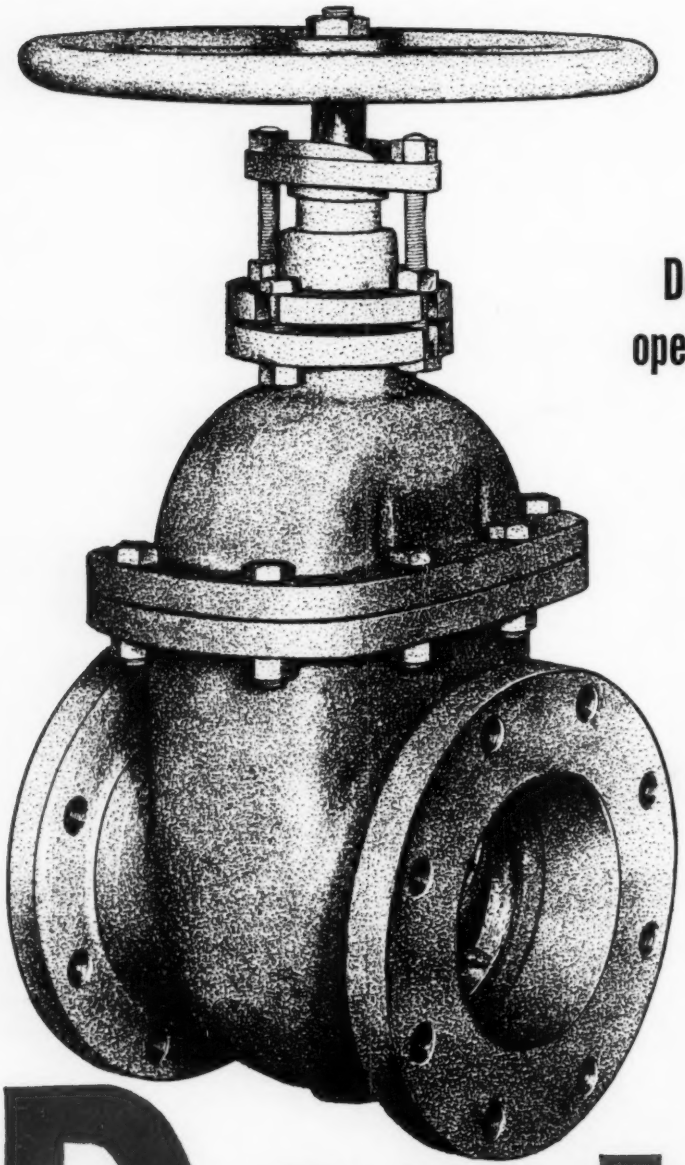

Dependable Darling Gate Valves open fully, close tight—with ease

The fully revolving double disc parallel seat and wedge design minimizes friction, avoids concentration of wear, and automatically compensates for valve seat deflection.

Gate discs are independently hung and free to revolve. They change their seating position at each closing. All working parts are perfectly plain. There are no pockets to collect sediment or prevent free and easy movement.

For assured ease of operation, minimum maintenance, long trouble-free service life, *you can depend on Darling*. Our engineers are always glad to assist you in determining the right valves for your service conditions. Darling Catalog No. 57 gives complete specifications. Write for your copy today.

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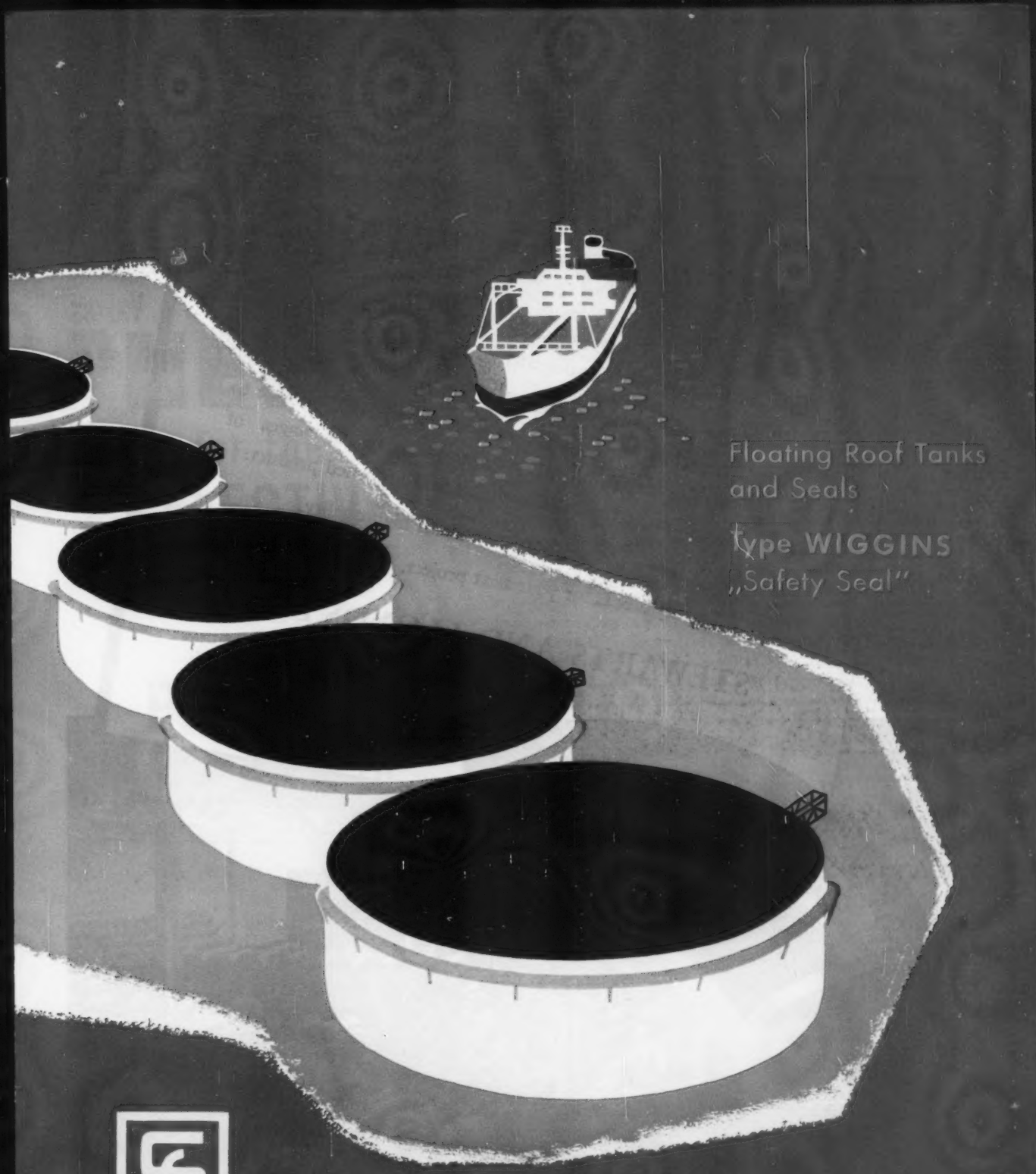

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4 "NEWS" for the SELECTIVE BUYER!

PACIFIC types DS and DL *Double Volute Double Suction*

single stage centrifugal pumps

Write for Bulletin 143

PACIFIC PUMPS
Inc... A Division of Dresser Industries, Inc.
HUNTINGTON PARK, CALIFORNIA, U.S.A.

1 NEW QUALITY – All DS and DL pumps are skillfully molded from meticulously fabricated patterns to provide smooth exterior and interior contours and controlled case thicknesses. All parts in contact with liquid being pumped may be fabricated from any commercially available ferrous or non-ferrous metal.

2 NEW DESIGN – Types DS and DL are *double volute* with double suction impeller. Shaft assemblies are dynamically balanced, radially and axially for minimum wear. Cases are axially split with nozzles cast integral with lower half. Type DS has provisions for water cooled packing boxes and bearings. Type DL is air cooled. Available with conventional packing or mechanical seals. Internal assemblies are mounted on only six shaft size groups for maximum parts interchangeability between pump sizes.

3 NEW PERFORMANCE – With a capacity range from 2,000 to 13,000 GPM and differential heads to 375 ft., the 22 sizes of type DS and the 13 sizes of type DL, make it unnecessary to compromise your specific pumping requirements – i. e., optimum efficiency with low NSPH.

4 NEW ECONOMY – Pacific types DS and DL pumps offer threefold economy. First, engineering skill and expert craftsmanship reduce the initial cost appreciably. Second, the balanced hydraulic design results in minimum wear on moving parts insuring higher sustained efficiency. Third, rapid disassembly plus maximum spare parts interchangeability between pump sizes assures reduced maintenance costs – less down time.

PACIFIC
CENTRIFUGAL PUMPS FOR PETROLEUM, CHEMICAL, UTILITY & GENERAL INDUSTRIES
OIL WELL PUMPS

DRESSER INDUSTRIES INC.
OIL • GAS • CHEMICAL
ELECTRONIC • INDUSTRIAL

CP-26

For more data on advertised products, use cards, last page.

Octanes at 1950 cost

After years of rising costs for materials and labor, this may seem like an extravagant statement, but "Ethyl" antiknock compounds today cost just about the same as in 1950.

Octane improvement through antiknocks, always an economical, flexible method, is now even more attractive. A variety of antiknocks that give greater cost effectiveness in selected stocks, plus current antiknock cost, makes the increased use of antiknocks a more attractive route than ever toward the most economical production of gasoline.

In addition to offering low octane improvement costs, lead antiknock compounds provide an important road-performance bonus—a bonus that can come only from antiknocks and which increases with higher lead concentrations. Further, gasoline sensitivity can be decreased through the use of antiknocks.

These factors all add up to the need for a new look at octane-improvement costs and a reappraisal of the balance between antiknocks and processing.

Ethyl will be glad to help in evaluating your octane-improvement program. Linear-programming specialists will assist you in determining the proper allocation of components and optimum antiknock concentration, as well as selecting the most effective antiknock compounds from the wide range now available.

"Ethyl" antiknock compounds, always a good buy, are now even better than ever. Ask your Ethyl representative how you can use them to the greatest advantage.

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TECHNOLOGY

Radiation and formaldehyde

Gamma radiation of formaldehyde used in acetyl resins may be moving closer to commercial production. Japan's Toyo Rayon has been running 100-ton-per-year pilot unit, and will build commercial plant in 1962. Big question: Will they use radiation method or Du Pont's process? The company is using a nitrogen-cooled 1.3-million-electron-volt Van de Graff accelerator, with polymerization temperatures reaching 100° C or lower. Initial work on polymerization via radiation was done at Kyoto University, which used gamma radiation from cobalt-60, temperature of 80° C.

Several other Japanese firms are closely eyeing Toyo process, one of which has a 1-ton-per-month pilot plant on stream, using method similar to Du Pont process. Meanwhile, U.S. acetyl resin manufacturers watch closely for hint as to whether radiation technique is more economical than present methods.

Robot painter! What next?

A robot, resembling a small army tank, is being used by Humble Oil & Refining to prepare and paint relatively smooth metal surfaces both vertically and horizontally. Is it fast? You bet! One-half a foot per second. A successful preliminary model has been built by Esso Research. Applications center on large metal storage tanks and hulls and decks of ships.

How it works: Magnets set into rubber treads similar to those on armored tanks keep robot stuck to surfaces. Air-operated turbine connected to treads drives it. Direction is decided by operator using pneumatic controls, while paint is fed through hose under pressure. Pressurized roller applies paint after surfaces have been prepared by mechanical chipping tool in one continuous motion. Robot advantages: Can paint medium-sized tanker in 16 man-days, compared with 200 man-days manually. Net result: Big savings in painting costs.

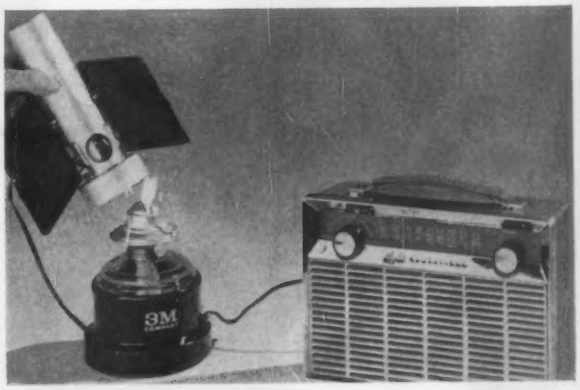
New phthalic process

New Von Heyden-Chemiebau fixed-bed phthalic process, which employs vanadium pentoxide poisoned with a potassium compound, will be used in new Allied Chemical plant on West Coast. Process features a very high yield, but has a slow space velocity in reactor. Company says its low sulfur contaminants may make it useful in petroleum naphthalene, high cost of which makes high yield important consideration.

A question for competitors: Does fact that process can use "variety of feedstocks" imply that process can be modified to accommodate ortho-xylene too? If so, ortho manufacturers will want to keep their eyes on this one. In store for Allied: A major processing switch, as company has previously used traditional low-yield, high-velocity phthalic process.

Eyeing alpha olefins

Long, straight-chain alpha olefins are being looked at carefully by several HPI companies, who wonder if these chemicals can move into big-volume arena. While these firms await better economic data before making definite move, they are looking over two methods to make alpha olefins. One uses a paraffin feedstock which is cracked. The other involves Ziegler chemistry to building chains from ethylene. Meanwhile, ethylene polymerization process for straight-chain alpha olefins is under development in Gulf Research pilot plant, with eye to commercial quantities.



For fallout shelters

New thermoelectric generator using kerosine as its heat source provides power necessary to operate transistor radios. Designed for use in fallout shelters, generator eliminates need for batteries in radios operating on 3 to 9 volts. Gadget was developed by Minnesota Mining & Manufacturing.

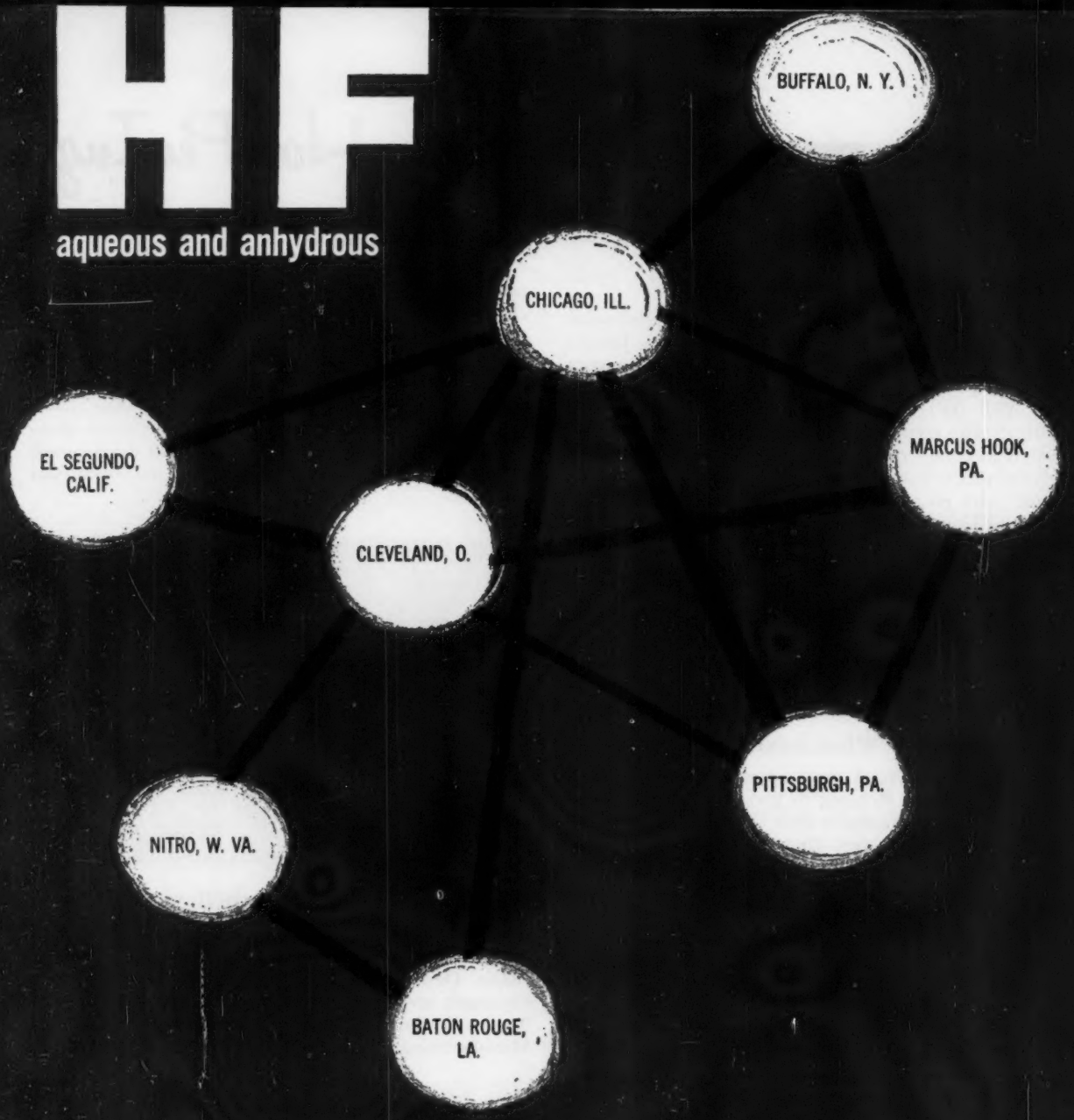
The speedy 'onstream'

Amid the enormous amount of construction going on in HPI (see Construction Boxscore, July 1961 issue, pages 229-242) one fact stands out like proverbial sore thumb—plants are being built faster than ever, with exception of war years. Reason for 25-percent increase in construction speed that has occurred over last five years, lies in better design and building methods. Method: More use of critical-path scheduling and models. Most engineer-constructors now use models to supplement drawings, thus giving added advantage of three-dimensional perception.

As for critical-path scheduling: Unlike use of models, main advantage of which is to shrink man-hours, CPS highlights critical operations sequence so more workers or overtime can be applied to critical jobs. Further attribute of CPS: Increased man-hours for expediting and purchasing. Thus, modeling and CPS appear to be perfect marriage in contracting costs. The summing up: Even if cost of living index, to which labor costs are

HF

aqueous and anhydrous



General Chemical's supply network is built around your needs for HF

General Chemical's multiple production facilities for anhydrous and aqueous Hydrofluoric Acid make us the *only* supplier to offer shipment from more than one plant! Our plants are located at Baton Rouge, La.; Marcus Hook, Pa.; and Nitro, W. Va. Deliveries of aqueous acid are also made from five strategically-located bulk storage plants in Buffalo, Chicago, Cleveland, El Segundo (California), and Pittsburgh.

This smoothly-coordinated production and delivery system is backed by a long lifeline of raw material sources: fluorspar reserves, mines, mills, and large sulfuric acid capacity.

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closely tied, cancels out part of advantage in saved man-hours, fact that plant comes on stream sooner means quicker return on investment—faster payout.

Ammonium nitrate fire hazards

Fire hazards of ammonium nitrate and related materials will be studied by U.S. Bureau of Mines and Manufacturing Chemists' Association in one-year research project. Manufacturing Chemists will bear entire $60,000 cost of project. It will cover fire hazards of nitric acid-hydrocarbon, ammonium nitrate-urea and combinations of these systems, in addition to ammonium nitrate. Research highlights: Effect of contaminants, and confinement and detonability of solid and molten ammonium nitrate; sensitivity to initiation by close proximity detonation of other explosive systems.

Chemicals to serve commuters

Commuters soon can get a view of how chemicals might enable them to travel swiftly, luxuriously and economically—and without traffic congestion—in 21st century. Operating model of futuristic monorail system, powered by converting chemicals directly into electrical energy in fuel cells, is being built at Electric Storage Battery's Exide Industrial Division, Philadelphia. Exide has also made fuel-cell-powered midget automobile. Why fuel cells have potential: They are capable of power efficiencies at least double those of best conventional engines and generators. They have no need for intermediate steps of combustion or steam production with resulting losses of power through friction and dissipation of heat.

ASTM changes, studies

Capillary gas chromatography can analyze aviation gasolines with greater precision than conventional methods, according to study at recent ASTM Committee D-2 meeting. Also, flame ionization detectors and capillary columns were found to be applicable to quantitative analysis of many petroleum products.

Other ASTM measures: (1) Changes in gravity, viscosity and distillation requirements for No. 2 fuel oils approved. These changes narrow range of fuels that can meet the specification D 396. (2) Methods for determining TEL in gasoline revised to make them applicable to testing gasolines containing both TEL and TML. New reference fuels to be proposed in 1962 for cetane engine test method. New fuels will be a purer n-cetane (100 cetane number) and heptamethyl-nonane (15 cetane number). Heptamethyl-nonane (HMN) will replace current low-cetane number reference fuel, alphamethyl-naphthalene.

PRODUCTS

Construction plastics on move

Construction-industry demand for plastics is on the rise, according to new Monsanto Chemical report, which says 1960 market hit 1.4 billion pounds, about 24 percent of industry's production. Construction applications accounted for about 9.7 million pounds of plastics, while 428 million pounds went into alkyd resins, modified rosin, coumarone-indine and petroleum polymers used in paints and flooring. Most widely used in construction applications are vinyls, with 305 million pounds in 1960. Phenolics hit 184 million pounds in '60.

What's ahead in plastic pipe

High-density polyethylene pipe is getting more and more attention, with an eye to increased plant applications. Plastic pipe has been around several years, but most spec writers and constructors are waiting for better operating data before going whole hog. Among questions in their minds: Will long stretches "sag" without expensive stanchions and supports? (which are expensive enough to discourage average spec writer).

Meanwhile, traditional advantages remain attractive: inexpensive installation, light weight, low maintenance cost, inside wall smoothness, and impact strength. When strength and other factors have been resolved, possibly within next five years, look for wide and varied plastic piping in plant.

Coming up: polyolefin tire cords

Polyolefin tire cords have petrochemical manufacturers scrambling for better olefin polymers, with an eye to 400-million-pound-per-year market. Research is underway by a number of companies, all of which are keeping quiet because of attractive, big tire-cord market. One such firm is Goodyear, which is making pilot plant studies of polyolefin fibers, and has built some experimental tires. Big advantage over nylon and rayon tires is price. The problem: Can manufacturers whip inherent polyolefin problems of low temperature resistance, flat spotting, and difficulty of binding material into tires?

Center of attention is being held by polymers of 4-methyl-1-pentane and 3-methyl-1-butene. Also, Houdry is pushing polymer of 3,3-dimethyl-1-butene, made with its dehydrogenation process.

Highlights of plastic foam

Look for some welcome improvements in at least three major industries, thanks to important research developments in plastic foam. Outlook: New applications in refrigeration, construction and pleasure craft fields should lead way to potential market for rigid urethane foams that could top 100 million pounds within five years. Now chemists have worked out new ways to use one important characteristic of plastic foam—its bubbles.

However, there is one problem: How to harness the holes into a suitably versatile, efficient and strong mate-

need help on foaming problems?

If you operate a gas treating unit using ethanolamines or ethylene glycols, chances are foam is nothing new to you. It's not necessarily a sign of trouble. But if foam is too stable, you may soon be up to your ears in foaming problems.

What to do: Proper care of the amine or glycol solution is the best cure for foaming problems. Start with materials of guaranteed purity, ethanolamines and ethylene glycol from Allied Chemical.

- In amine systems, first preventive steps are proper reclaimer operation and adequate filtration – using activated charcoal, in some cases, to adsorb foam-generating materials.
- In glycol systems, first steps are proper pH control, adequate filtration and provision for good separation of hydrocarbons and glycols.

How to rate your unit on foam: Bubble air through a 50-ml. sample of plant solution in a graduated cylinder, using either a medium or fine fritted glass dispersion tube. You'll need a means of measuring air flow so rates will be reproducible. Use two or three rates—e.g., .03, .05, and .10 cu.ft./min. Both at room temperature and at about 50°C (122°F), observe:

1. Type foam formed (bubble size, apparent consistency).
2. Time required for foam to reach maximum height.
3. Time required for foam to break after air flow is stopped.

Repeat same test on equivalent amine or glycol solutions made up from fresh, unused amine or glycol and compare results. If the plant solution has an appreciably greater tendency to form stable foams of uniformly large bubble size, get ready for trouble.

What about foam inhibitors: Remember, these don't solve the basic problems, but merely give control until you locate the cause of the foam and correct it. Also, how they act may depend on whether they are added *before* or *after* the foam is generated.

For more help, write for "Report on Foaming Problems". We'll also be glad to send you technical data, delivery and price information on Allied Chemical Ethanolamines and Ethylene Glycols.

For specs and local offices, see Chem. Materials Catalog, page 272A; Chem. Week Buyer's Guide, page 27. 2819

Allied Chemical

BASIC TO AMERICA'S PROGRESS

NITROGEN DIVISION

Dept. GA6-21-2, 40 Rector St., New York 6, N.Y.

rial. Here's how chemists have solved it: Plastic is stiffened, resulting in rigid foam that has load-bearing as well as insulating properties. Foaming methods permit material to be prefoamed into slabs to be cut to size and shape required.

Good news for methanol

Methanol, among other chemicals, will feel impact of moves to increase U.S. armed strength as result of Berlin crisis. Methanol's outlook: Suspension of phasing-out program for obsolescent B-47 bombers, which use anti-detonant injection (ADI) fluid. Each B-47, it's estimated, uses 200 gallons of methanol per takeoff. More good news for methanol: Many piston-engine planes employed by Military Air Transport Service use ADI fluid—up to four gallons of methanol per engine per takeoff. Petroleum industry as a whole will be making more higher-octane military aviation fuel should an airlift necessity develop, causing a tighter hold on toluene supplies at refineries.

ECONOMICS

Equipment tax credit

Capital equipment investments are being encouraged by House Ways and Means Committee proposal. Their idea: A credit against taxes on 8 percent of money put into equipment with useful life of six or more years. Only 50 percent of company's total taxes would be eligible for credit—but limit would not apply to tax liability on first $100,000.

Administration had earlier proposed tax credits correlated to capital spending and allowances for depreciation. Look for House to debate tax reform bill this month. However, there is little chance Senate will have time to act before end of present session.

Polyethers and competition

The seven major polyether producers (Allied, Carbide, Wyandotte, Dow, Jefferson, Atlas, and Olin Mathieson) have a keenly competitive road ahead now that Allied is up with its 20-million-pound-per-year Baton Rouge plant. "Big Seven" could hardly be referred to as the "Seven Dwarfs"—with potential to make 230 million pounds of polyethers a year. The problem: Present consumption is at only 70 million pounds, and supply-demand balance isn't expected until 1965.

Meanwhile, polyether manufacturers tread a dangerous road where they could have a head-on collision with disorderly price slashes and lowering of product standards because of competition. The big picture: Polyether consumption by fast-growing urethane market should reach 200 million pounds by '65—triple the present level. In flexible urethane foam, about 70 percent of finished product's weight is made up of polyethers, which have almost completely plowed polyesters under.

No "ABA" for engineers

For years, many interested in fostering "professional" image of engineers through a unified organization (such as American Bar Association) have dreamed of a sort of "super-society" to promote engineering profession. Dream grew bright early last year with proposed merger of Engineers Council for Professional Development and Engineers Joint Council, and between National Society of Professional Engineers and ECPD. But now hopes have faded for supporters of ideas, at least for the time being. One reason: ECPD does not want to give up its tax exempt status as non-profit organization. EJC, on other hand, is classified as lobbying group, so must pay taxes.

EJC has voted for the merger, but five groups of the ten-group ECPD are against merger. Their position: Present clean cut lines of responsibility between organization would be clouded by one big association. Traditional autonomy would be disrupted.

Crude consumption forecast

Domestic crude consumption for September is estimated at 7,075,000 bpd, compared with 7,150,000 bpd forecast for August, reports U.S. Bureau of Mines. Total gasoline demand is forecast at 4,410,000 bpd for September, and total crude runs are expected to hit 8,045,000 bpd. Gasoline demand prediction is 2.1 percent over September 1960 figure of 4,321,000 bpd. July crude runs to stills totaled 8,226,000 bpd, including foreign runs of 1,098,000 bpd. Domestic crude demand in July was indicated at 7,137,000 bpd. Over-all demand for July was about 6 percent higher than same 1960 period.

Professional retirement

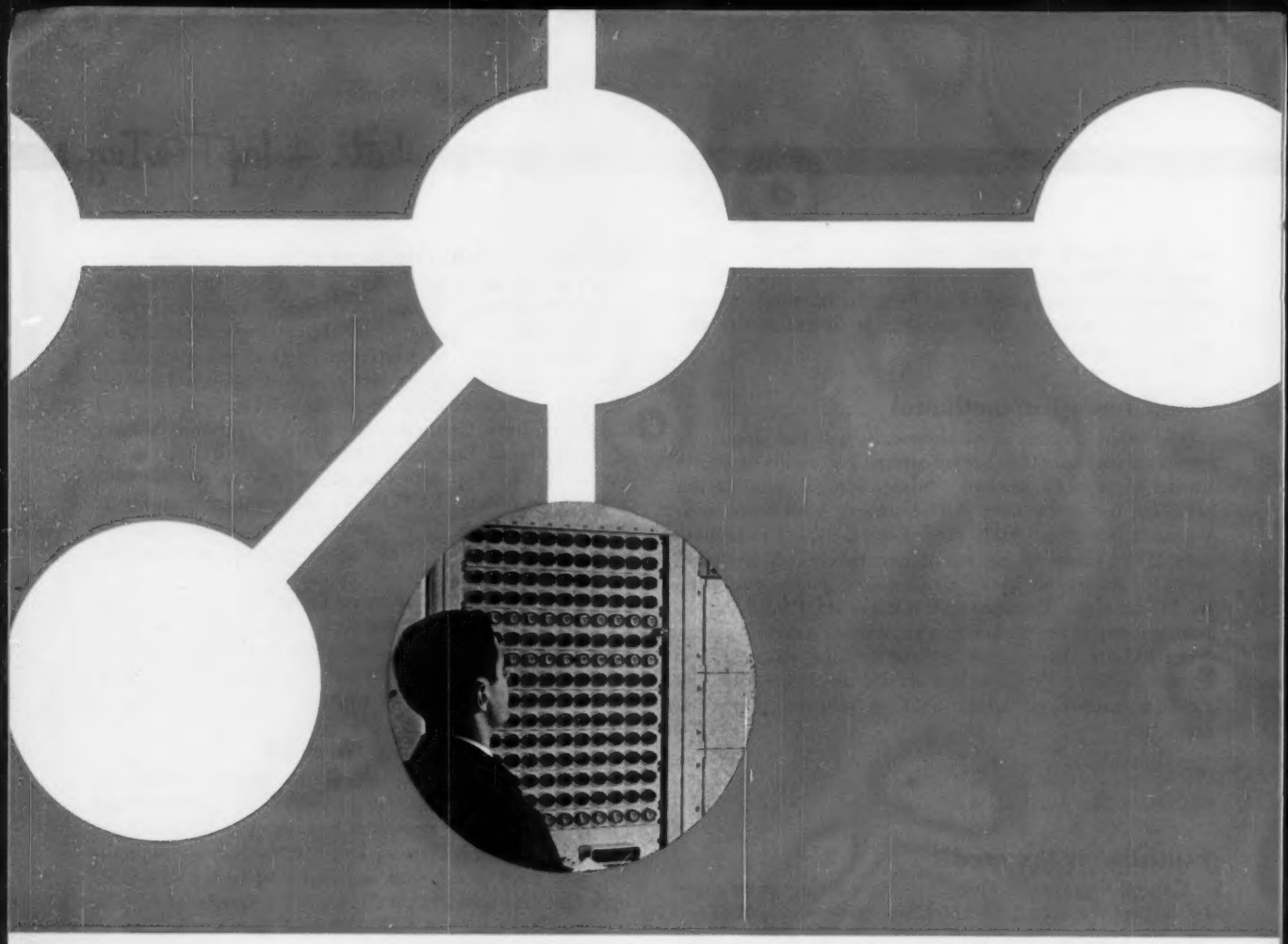
Present federal tax laws which inhibit self-employed professionals from establishing retirement programs are "roadblock" to development of self-reliant, individualistic consulting engineer, National Society of Professional Engineers has told Senate Finance Committee. Society's views: "A self-employed consulting engineer can materially increase his freedom of thought and activity with retirement benefits equal to those of his professional brothers who are not self-employed."

INTERNATIONAL

Engineers read and read and read

There is at least one area of agreement between U.S.S.R. and United States. Both say their scientists are being inundated by technical publications they must read to keep abreast of industrial developments. According to a new Soviet Institute of Scientific Research report, Russian engineers and scientists are spending 50 percent of their working time reading, while 35 percent of their time is spent on experimental research. The remaining 15 percent is consumed by writing, attending conferences, etc.

Especially time consuming is information search of



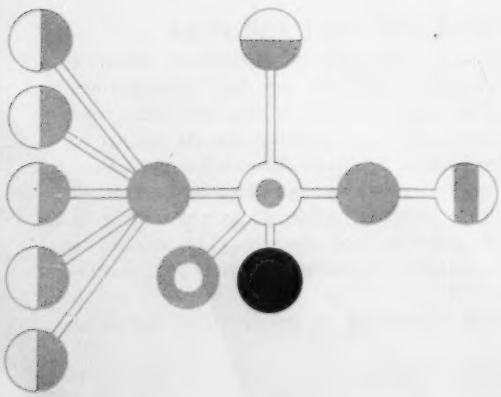
PROCESS PROTECTOR

Hagan AIM—centralized monitoring of all important variables

Temperatures, pressures, flows, levels, closures, in fact any input that can be represented by DC voltages as low as 10 millivolts full scale can be monitored by the Hagan AIM (Alarm Indicating Monitor) with an accuracy of plus or minus 0.1% full scale.

Fast and reliable, the Hagan AIM is compact—for example, the readout and alarm panel for 200 alarm points will fit into a 19″ x 47¼″ panel area. Combining all alarm functions in one instrument, AIM can be set for high or low alarm points, or both. Seconds after a monitored variable goes out of bounds, AIM energizes the alarm light and sounds a warning horn. The horn can be shut off, but the light stays lit until the condition is corrected. AIM safeguards both equipment and process from the shattering damage that a single runaway variable can produce. Now *one* man can watchdog a complete process line, taking corrective action before damage is done.

AIM is one component of the complete Hagan line of process controls, which include primary elements, transducers, controllers, recorders and final control elements. Designed for use with existing installations or for complete new systems, the Hagan line can save you money in terms of more accurate control with minimum adjustment and maintenance. For information, write or phone HAGAN CHEMICALS AND CONTROLS, INC., Hagan Center, Pittsburgh 30, Pa.



HAGAN

the physical sciences. Say the Russians: The traditional theory of bibliography and library science cannot satisfy requirements stemming out of information-control problems. "None of the 350 types of library classifications are satisfactory," according to Soviet documentation experts. The resulting waste of scientific manpower and money was pointed up in the 1958 International Conference on Scientific Information, held in Washington, which also showed United States is in same dilemma. This was further substantiated by a National Science Foundation study last year.

Reds seek radiation-hydrazine method

U.S.S.R. is on bandwagon searching for commercially adaptable radiation hydrazine process, as Soviet Psyicochemical Institute imini L. Ya. Karpov reports studies using high gamma radiation intensity (25-790 roentgens per second) at temperatures from —200 to 40° C. They found yield was best from liquid ammonia just above its freezing point.

Similar process was announced last December by Aerojet-General Nucleonics, but company has admitted inefficiencies and has gone back for more data. If low cost route to high-purity hydrazine comes about, atom-bomb-type research may prove key to fueling rocket that carries atom bomb to knock out enemy atom-bomb fuel plant.

Eyes on Italy's imports

Five countries in Europe's Common Market have their eyes on Italy as a block against Soviet Union crude imports. If Italy does not cooperate, look for these five to propose closing their borders on Italian products. Portion of Common Market Rome treaty may be basis for this threat. However, three main problems are seen in attempting enforcement:

- No one has succeeded in proving Italy's oil exports contain products refined from Russian crude.
- Other Common Market nations also import Soviet-bloc oil.
- Italy's Soviet oil imports cannot be blamed entirely for impairing economic situation in other Common Market countries as long as some Soviet offers are cut out by cheaper domestic prices.

Dig this cave!
Storage vessel for propane at Sun Oil's Marcus Hook, Pa., refinery—biggest cavern ever hewn from solid granite.

Foreign oil spending higher

Foreign spending in petroleum industry is expected to be higher this year than in 1960. U.S. Commerce Department's Survey of Current Business reveals capital investment in plant and equipment will be $1.8 billion, compared with $1.5 billion last year. Reasons for upturn: Development in North African production; improved refining and distribution in Europe.

GOVERNMENT

Attack on import allocation

Jersey Standard has filed action in District of Columbia district court seeking declaratory judgment. The charge: Method of allocating crude oil imports to individual importers under oil import program fails to meet requirements of President's proclamation that there should be a "fair and equitable distribution" of allowable imports. Method was adopted in March 1959 and has continued in effect since then.

Says Jersey: Method is unfair, inequitable, arbitrary and discriminatory. Law suit names as defendants Stewart L. Udall, as Interior secretary, and Lawrence J. O'Connor, Jr., as administrator of Oil Import Administration. Company stressed fact it is not attacking control of oil imports as provided for in President's proclamation. On the contrary, said Jersey Standard, regulations do not comply with requirements of proclamation.

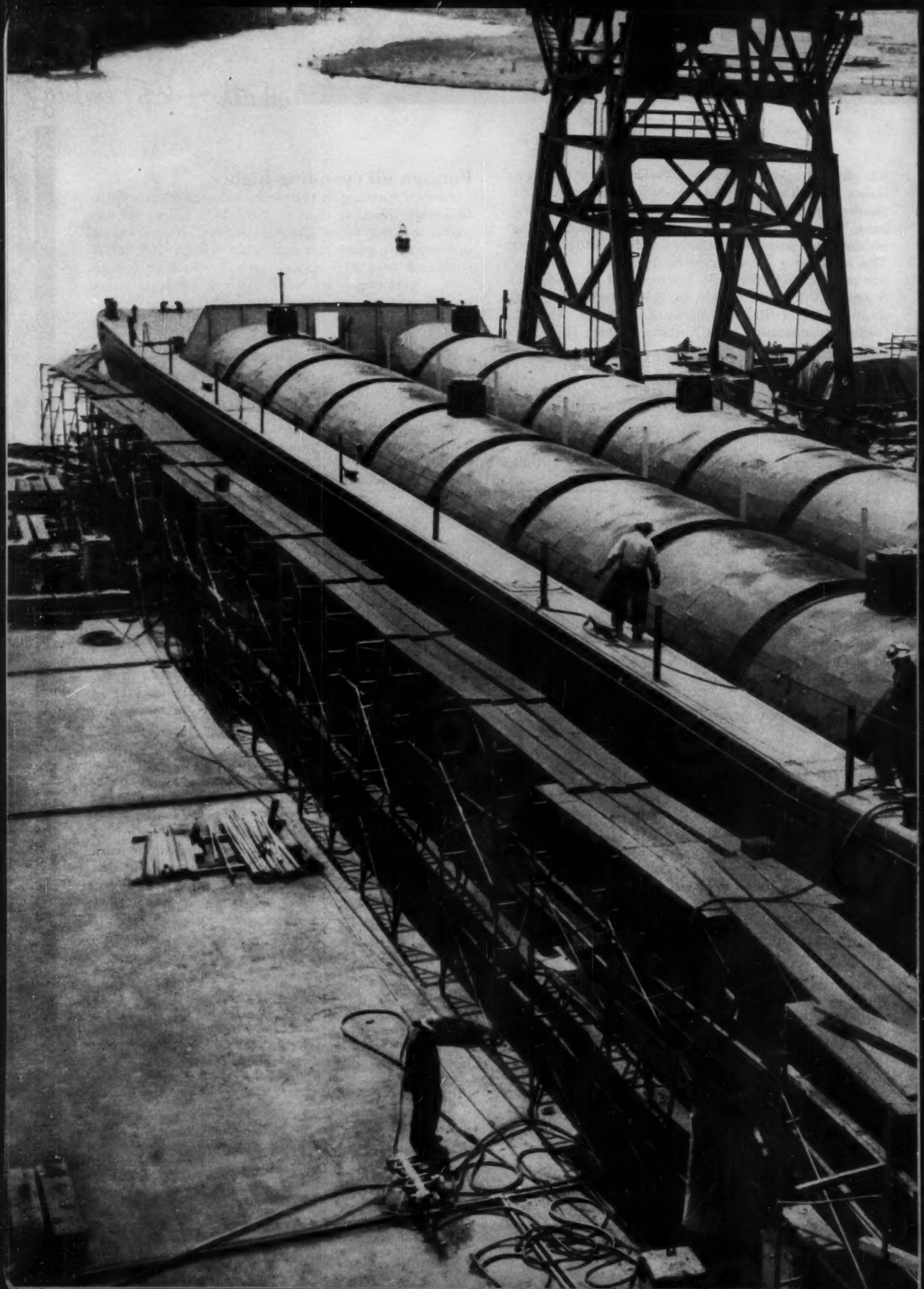
Its allocation, company pointed out, has been determined according to sliding scale which discriminates among refiners based on quantity of their refinery inputs. Further, company contends that if purpose of import program is to stimulate domestic crude oil exploration and production, there is no justification for present allocation system which gives unequal treatment to competitive refiners.

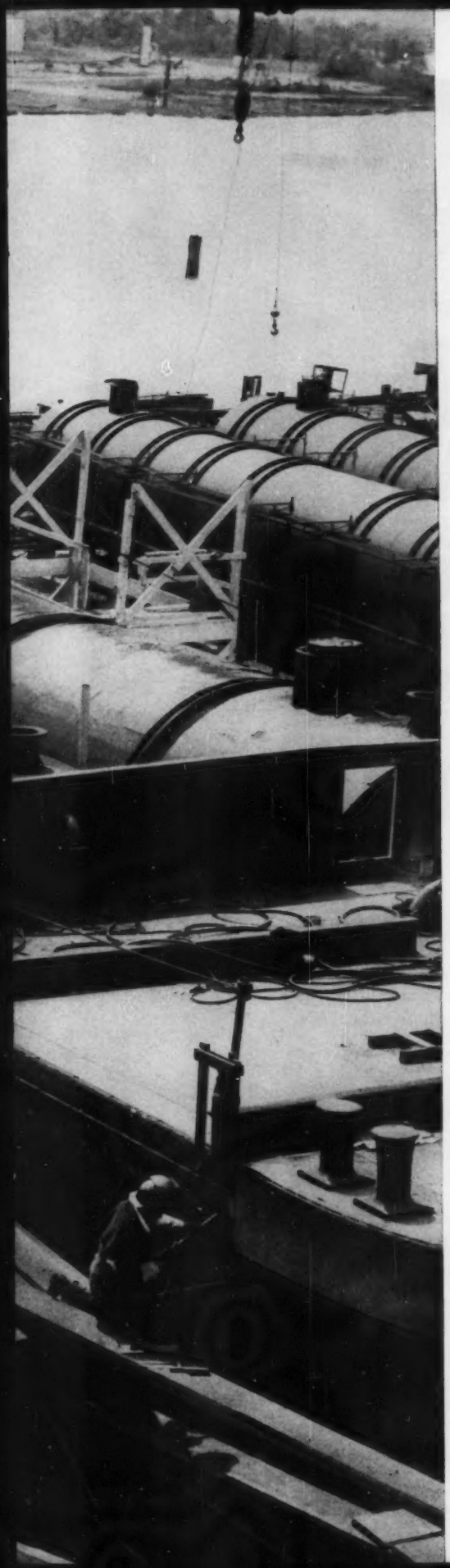
NPRA's comment on suit: "We will resist strongly any change in formula which affects adversely competitive position of smaller refiner." Teaming up with NPRA, Independent Refiners Association stated it will use "every proper and legally available route" to curb Jersey Standard's attack on sliding scale system.

Helium conservation

First contract under new helium conservation program is approved by U.S. Interior Department. Program is designed to conserve 52 billion cubic feet of helium that

for more about what's happening in HPI, turn to Page 327





Noah never had it so good!

We weren't around when Noah needed a good design for his transportation problem, but *NaOH* (caustic soda) has had it *real* good since our Naval Architects developed these barges specifically for the transportation of over 1,200 tons of Sodium Hydroxide.

The 195′ barges are each fitted with two cylindrical cargo tanks. The tanks are specially lined to prevent iron pick-up by the cargo, and are so well insulated that no supplementary heating is required prior to unloading. In addition to sodium hydroxide, the barges have been certified by the United States Coast Guard for the transportation of other Grade E products compatible with the lining.

American Bridge designers put the cargo tanks under a steel "house" to protect the insulation from the elements and to prevent swamping. Unique arrangement of the pumps and piping on the tank shelter reduced the over-all height of the barges so that ballasting under extremely low bridges will rarely be required.

High-strength, low-alloy USS COR-TEN steel was specified for hull plates primarily to combat corrosion. Although the 50% higher yield of COR-TEN would permit a reduction in thickness of the hull plates, normal scantlings were retained to give the barges longer life at minimum maintenance costs.

Whatever your plate needs, American Bridge has the staff and facilities to take care of them, and our strategic location permits shipment by train, truck or barge. Write for our booklet completely describing plate fabricating and construction services.

USS and COR-TEN are registered trademarks

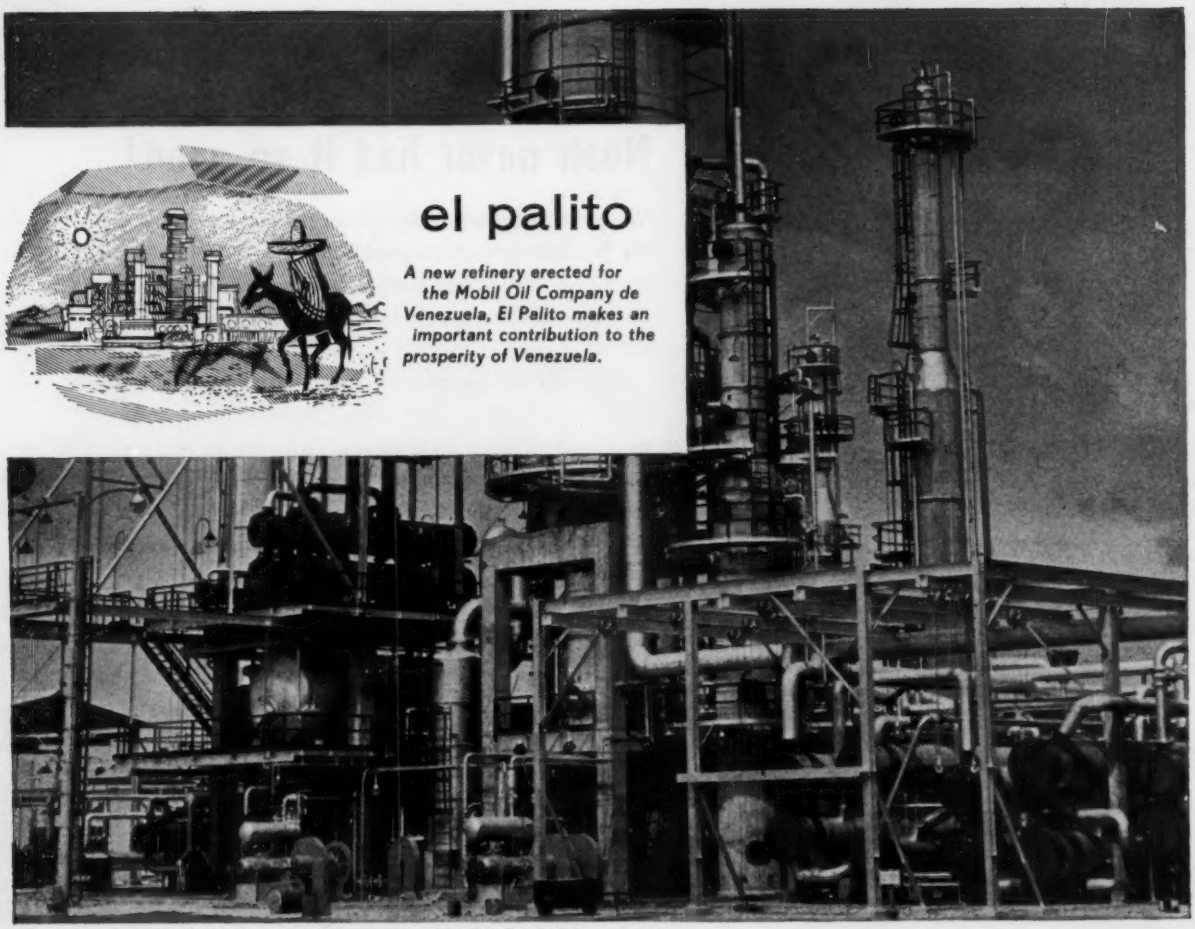
This mark tells you a product is made of modern, dependable Steel.

General Offices: 525 William Penn Place, Pittsburgh, Pa. Contracting Offices In: Ambridge Atlanta • Baltimore • Birmingham • Boston • Chicago • Cincinnati • Cleveland • Dallas Denver • Detroit • Elmira • Gary • Harrisburg, Pa. • Houston • Los Angeles • Memphis Minneapolis • New York • Orange, Texas • Philadelphia • Pittsburgh • Portland, Ore. • Roanoke St. Louis • San Francisco • Trenton • United States Steel Export Company, New York

USS **American Bridge Division of United States Steel**

el palito

A new refinery erected for the Mobil Oil Company de Venezuela, El Palito makes an important contribution to the prosperity of Venezuela.



(Illustrated: Crude Distillation Unit and the Depropanizer and Straight Run Stabiliser columns).

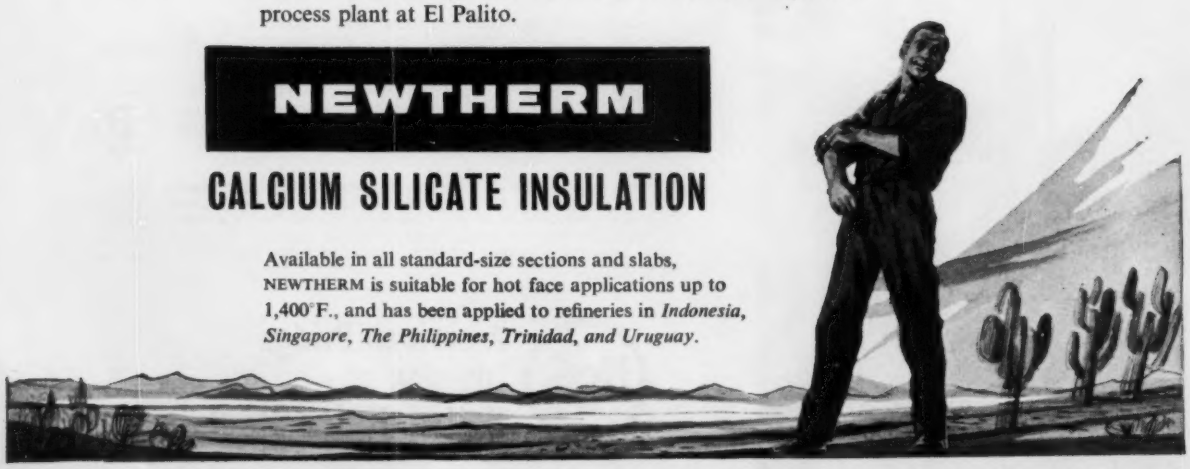
insulation assignment at El Palito

A growing number of refinery insulation engineers are turning to NEWALLS (Regd Brand) NEWTHERM Calcium Silicate Insulation—the insulation with qualities of particular significance in this field. Strong, yet of very light weight—moisture resistant and easily applied, NEWTHERM was specified for much of the more important process plant at El Palito.

NEWTHERM

CALCIUM SILICATE INSULATION

Available in all standard-size sections and slabs, NEWTHERM is suitable for hot face applications up to 1,400°F., and has been applied to refineries in *Indonesia, Singapore, The Philippines, Trinidad, and Uruguay.*



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IF IT'S BY CHIYODA IT'S BOUND TO BE GOOD

By "Good" we mean that CHIYODA's Process Plant Specialists (Engineering, Fabrication and Construction) have the technical know-how and modern, completely equipped facilities to handle your Process Plant needs and problems—large or small—from drawing-board to finished product and produce the results that count: Peerless quality, competitive prices and early delivery.

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NO. 3, MARUNOUCHI 2-CHOME, CHIYODA-KU, TOKYO, JAPAN
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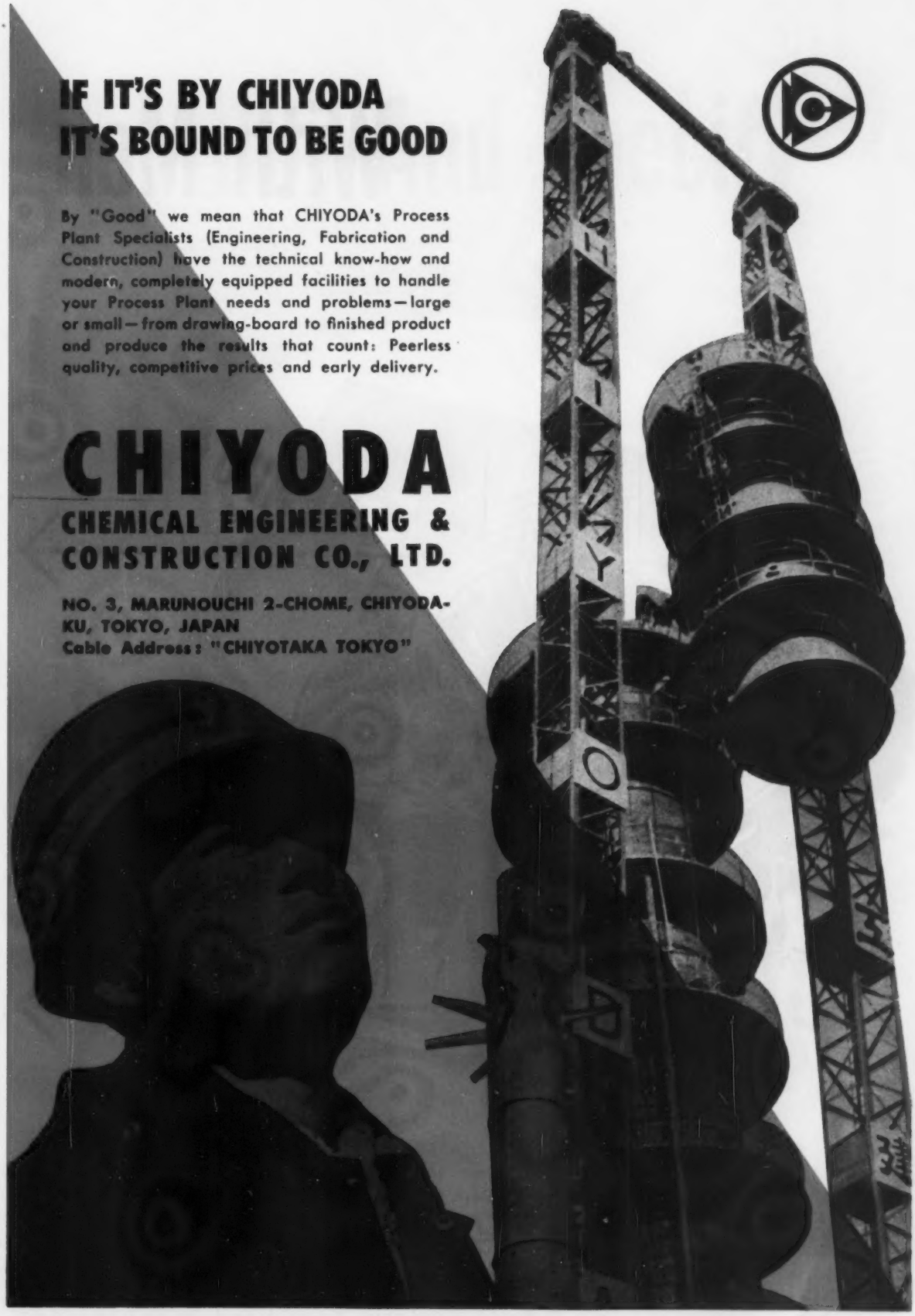
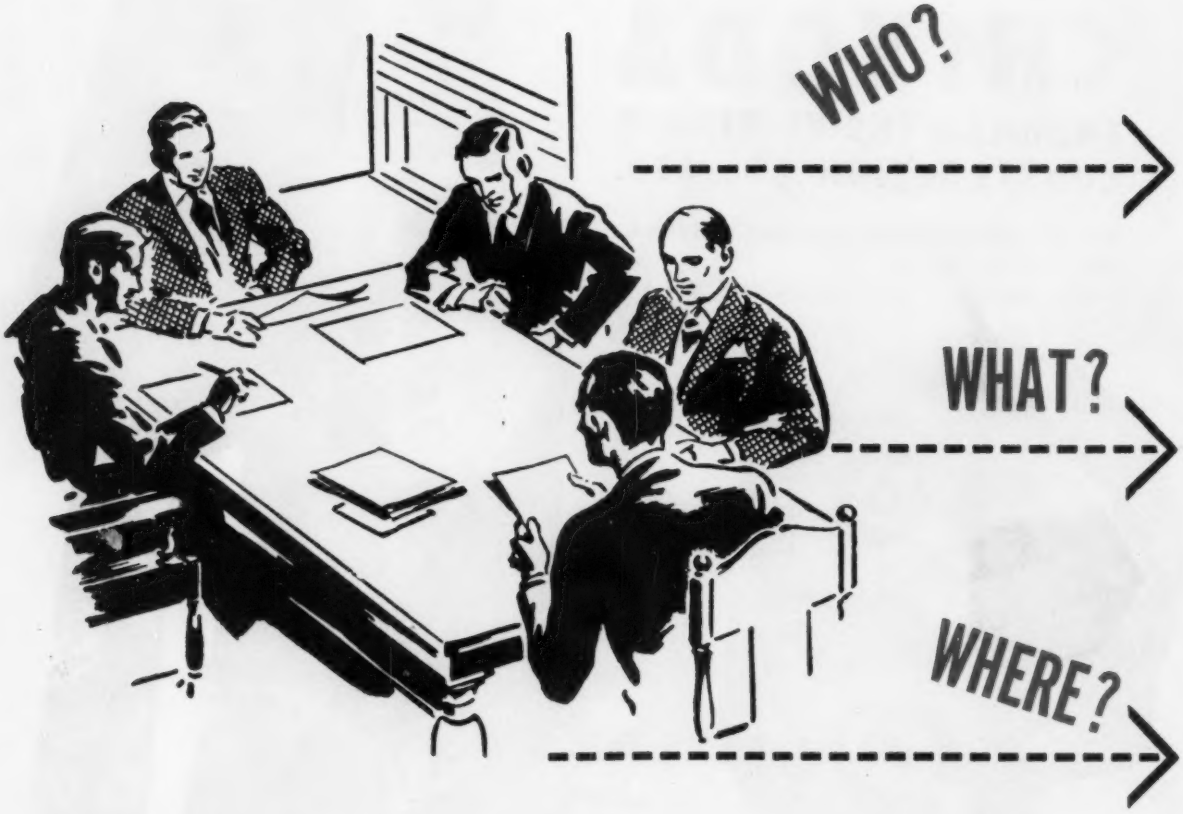


With Men

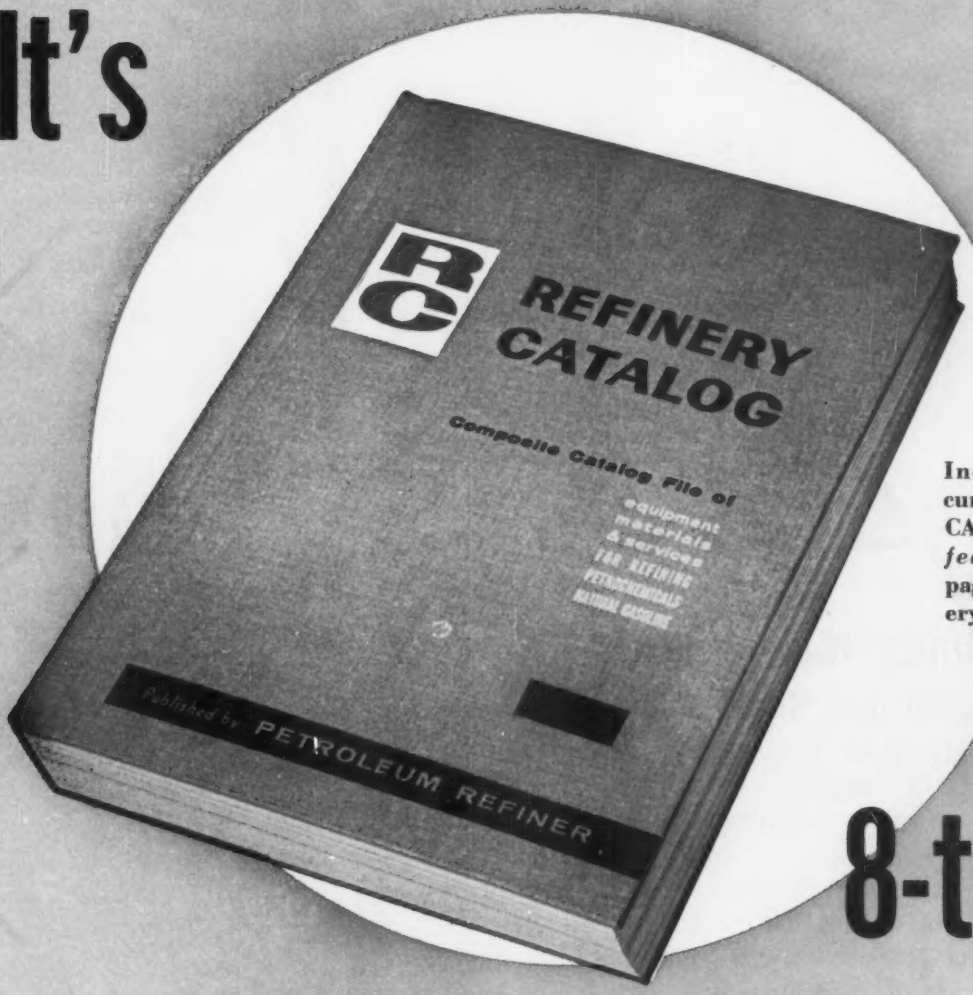


REFINERY CATALOG

Published by Petroleum Refiner

Who Buy And Specify

It's



Included in the current REFINERY CATALOG is a *new feature*—the 128-page A·S·A Refinery Piping Code

8-to-1

Look to REFINERY CATALOG for quick answers to your procurement problems in the refining, natural gasoline and petrochemical industry. It's indexed and cross-referenced to save time and eliminate error in planning, buying and specifying for this fast-moving market. That's why buyers and specifiers express a preference of 8-to-1 for REFINERY CATALOG over individual product catalogs.

The next time *you* sit down to figure a job, look *first* in REFINERY CATALOG. You'll find it contributes to greater speed and accuracy.

Petrochemical Plants

from "on-paper to on-stream" with JGC

Japan Gasoline Co., can plan, design, procure, and build petrochemical plants around the world. JGC coordinates every detail at every step to deliver plants at maximum speed, within the budget.

Since 1928, JGC engineers planned over 600 projects from the ground up. These ranged from experimental pilot plants to multi-million dollar chemical, petrochemical, and petroleum refineries.

Some of JGC's current projects include a 45,000 T/Y Ethylene Unit and a 1,700 BPD Aromatic Extraction and Fractionation Unit.

If you plan to build a new process system or modify your present one, JGC's integrated operation can work to your advantage. For details write Japan Gasoline Co., Ltd., New Ohtemachi Bldg., Chiyoda-ku, Tokyo.

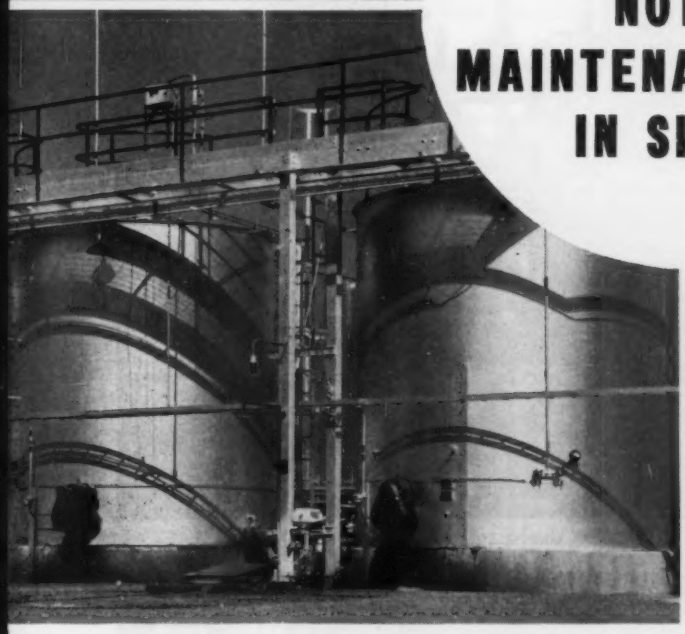
JGC

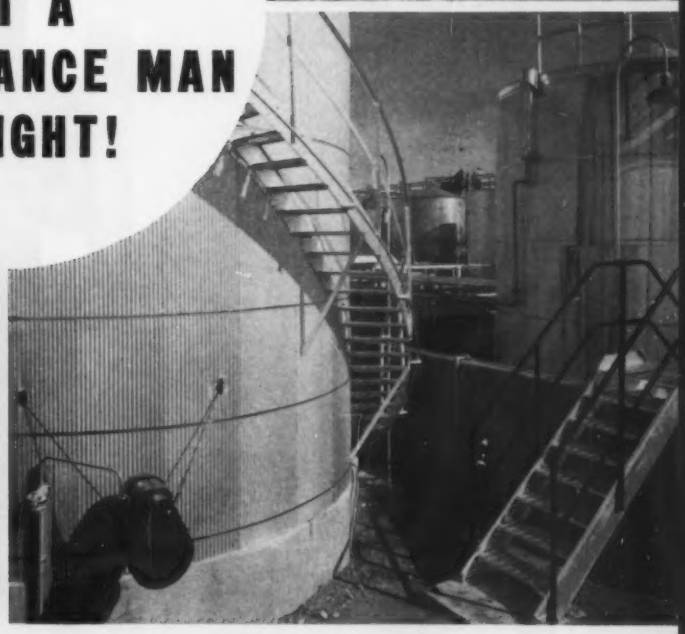
Engineers & Constructors

JAPAN GASOLINE CO., LTD.

Process engineering from "on-paper to on-stream"

TROUBLE-FREE MIXING... NOT A MAINTENANCE MAN IN SIGHT!





Improved Processing Through Engineered Agitation

At Nettco, we believe the simpler the design, the more reliable and trouble-free the performance of a mixer.

Take the Nettco side drive mixer for petroleum and petrochemical applications. Its stuffing box is the easiest to repack — results in less downtime. But more important — you don't have to repack it as often as others. Proper spacing of bearings and the location of the stuffing box relative to the bearings assures its longer wear — guarantees precise alignment of shaft and stuffing box — permits only minimum shaft runout. And — if your particular application requires a mechanical seal, you'll find that the Nettco design, with a bearing at the seal, prevents shaft runout assuring maximum seal life. However, when a seal must be replaced, Nettco makes it easier and faster to change.

Then — there's the extra large chrome plated shaft. Chrome — because it gives it longer life; extra large — because resulting rigidity prevents flexing and excessive wear.

The high gear efficiency of Nettco side-drive mixers requires minimum horsepower. The operating cost is low and you pay no more for the know-how and imagination that make Nettco design refinements possible.

You can reduce maintenance cost and shutdown time on your mixing equipment. See Refinery Catalog or Chemical Engineering Catalog for the nearest Nettco Representative or write us direct for Bulletin 582. Nettco Corporation, 81 Tileston Street, Everett 49, Mass.

NETTCO

ENGINEERED AGITATION SPECIALISTS

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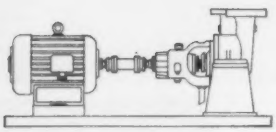
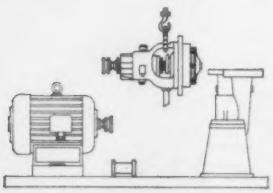
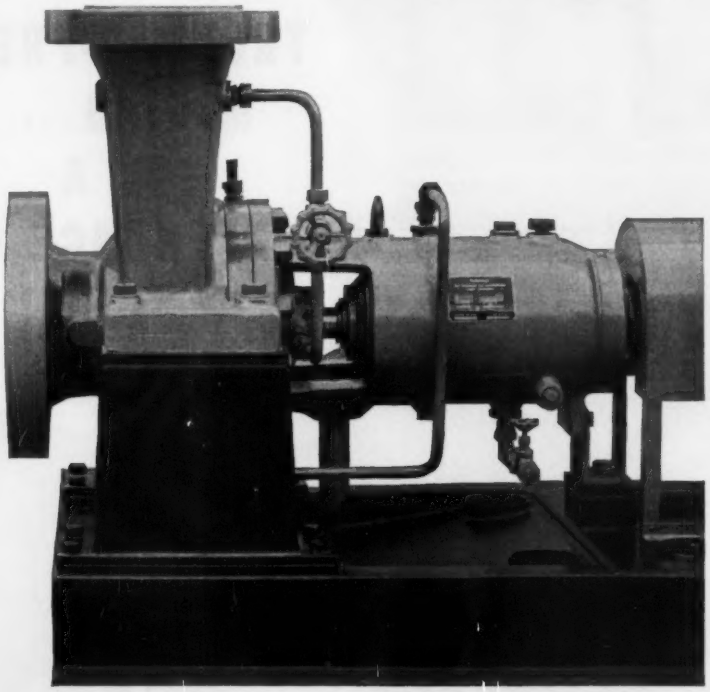






A 0440-5 E

RPK Process Pumps

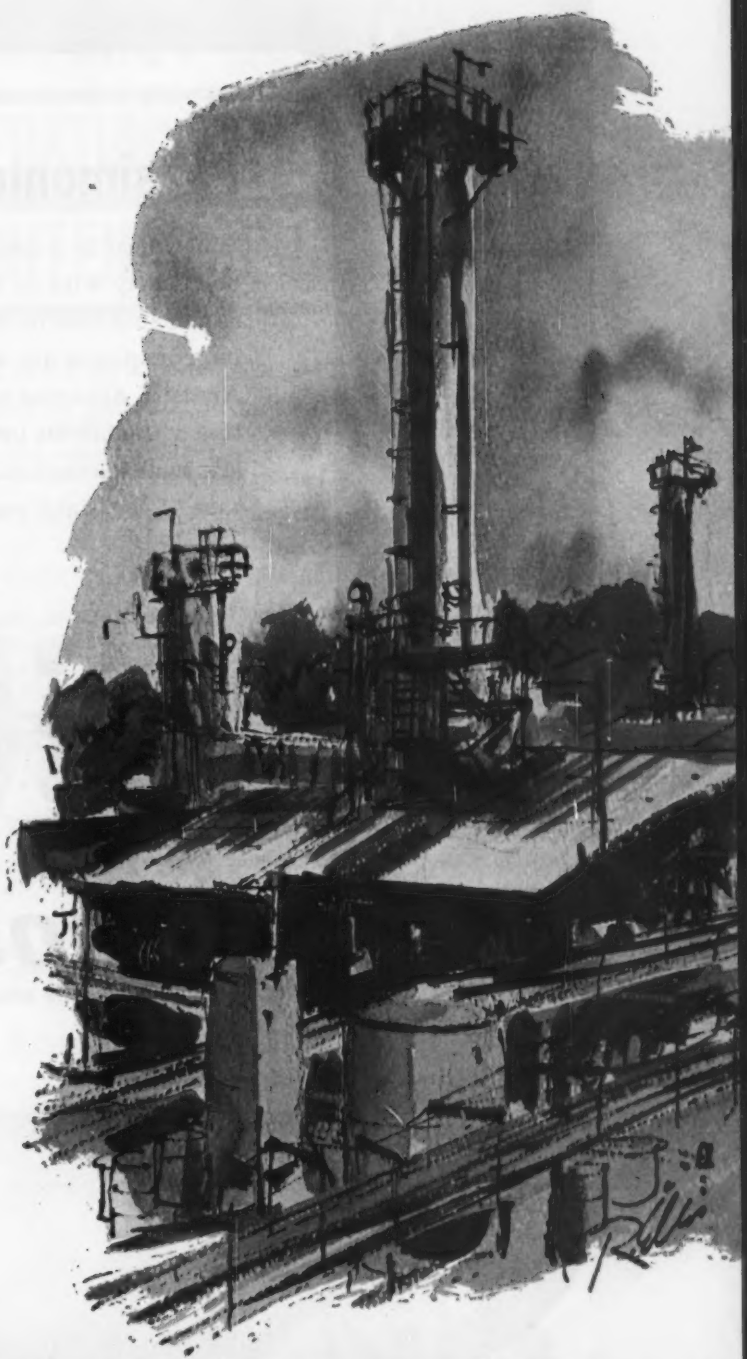
for handling hydrocarbons such as crude oil and its many distillates and derivatives at temperatures ranging from –165 to 850 F = –110 to 450 C.
These pumps are available in 22 sizes designed to ensure efficient performance at all operating points usually encountered, and special attention is paid to optimum NPSH values.
The great variety of operating conditions and the continuity of the production processes in refineries and the petrochemical industry are met by special design features that include
ready access to the interior of the pump for inspections and overhauls without having to lift the volute and the prime mover off the bedplate,
the possibility of interchanging any type of shaft seal without the efficiency being impaired and without the necessity of modifying the standing parts,
a reduction in the number of spare parts that have to be stocked by application of the unit construction principle so that the components of many sizes are identical.

KSB

Klein, Schanzlin & Becker Aktiengesellschaft, Frankenthal (Pfalz) Germany

CREATIVITY IN CUSTOM PROCESSING . . .

Truland offers an unusually broad spectrum of services and facilities of special interest to the process industries. These services range from original processing of raw materials for a finished product of strictest specifications to larger scale recovery of a wide variety of wastes, by-products and residues. This suggests a successful solution for you, from problem to product to package, all on a confidential custom basis.



THE TRUBEK LABORATORIES, INC.

TRULAND DIVISION
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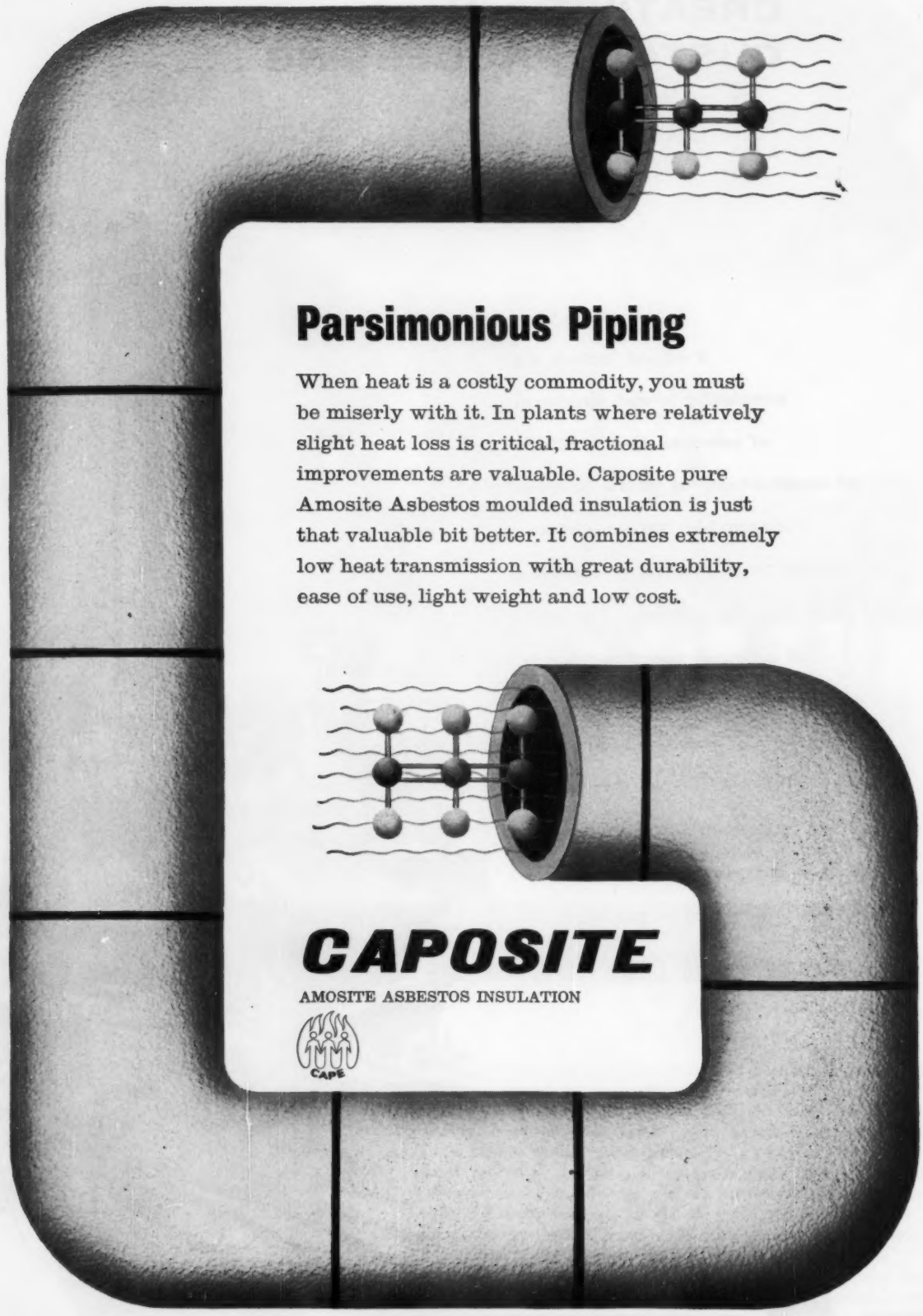

Parsimonious Piping

When heat is a costly commodity, you must be miserly with it. In plants where relatively slight heat loss is critical, fractional improvements are valuable. Caposite pure Amosite Asbestos moulded insulation is just that valuable bit better. It combines extremely low heat transmission with great durability, ease of use, light weight and low cost.

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CAPE

Enquiries to **Cape Insulation and Asbestos Products Ltd.** *A subsidiary of The Cape Asbestos Company Ltd.*
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TAS463

THREE MAIN OBJECTIVES COMMON TO ALL PLANT OPERATIONS...

UPGRADE PRODUCT QUALITY

IMPROVE OPERATING EFFICIENCY

REDUCE MAINTENANCE COSTS

. . . all important goals and a vital part of any plant operating program.

We at Warner Lewis Company believe that our products can contribute substantially to the achievement of these goals in your plant. With the experience and knowledge gained by countless in-plant applications of our water separator/filters we welcome the opportunity to discuss the installation and operation of our equipment with you.

Check this list for just a few of the many applications now serving the industry which might be of help to you:

UPGRADE PRODUCT QUALITY

_____1. Products to storage: Warner Lewis separator/filters remove essentially all solids and 100% of free or entrained water, even from product treated with corrosion inhibitors forming tight emulsions.

_____2. Caustic treating: Special Warner Lewis coalescing media remove traces of entrained caustic water from treating and washing operations.

_____3. Loading Rack: Warner Lewis separator/filters de-haze finished products, removing water cloud and solids such as catalyst fines. Insurance against costly customer complaint.

IMPROVE OPERATING EFFICIENCY

_____1. Warner Lewis separator/filters remove all free water and solids from process feed stocks, eliminate catalyst dilution.

_____2. Elimination of free water in process streams checks corrosion, cuts costly maintenance in heat exchangers and other process equipment, reduces inhibitor costs.

_____3. Where complete dehydration is used, Warner Lewis separator/filters ahead of desiccant beds, remove all free water and provide longer desiccant life.

REDUCE MAINTENANCE COSTS

_____1. 100% free water removal checks interior corrosion in lines, vessels and storage tanks, eliminates costly repairs or replacement.

_____2. Efficient filtration eliminates solids build-up in lines, vessels and storage tanks, eliminates costly cleaning operations.

_____3. Warner Lewis separator/filters prevent dilution or fouling of catalyst with water and solids.

FREE INFORMATION — Let us show you the economy of installing and operating Warner Lewis separator/filters in your plant. Mail this check list today to:

WARNER LEWIS COMPANY

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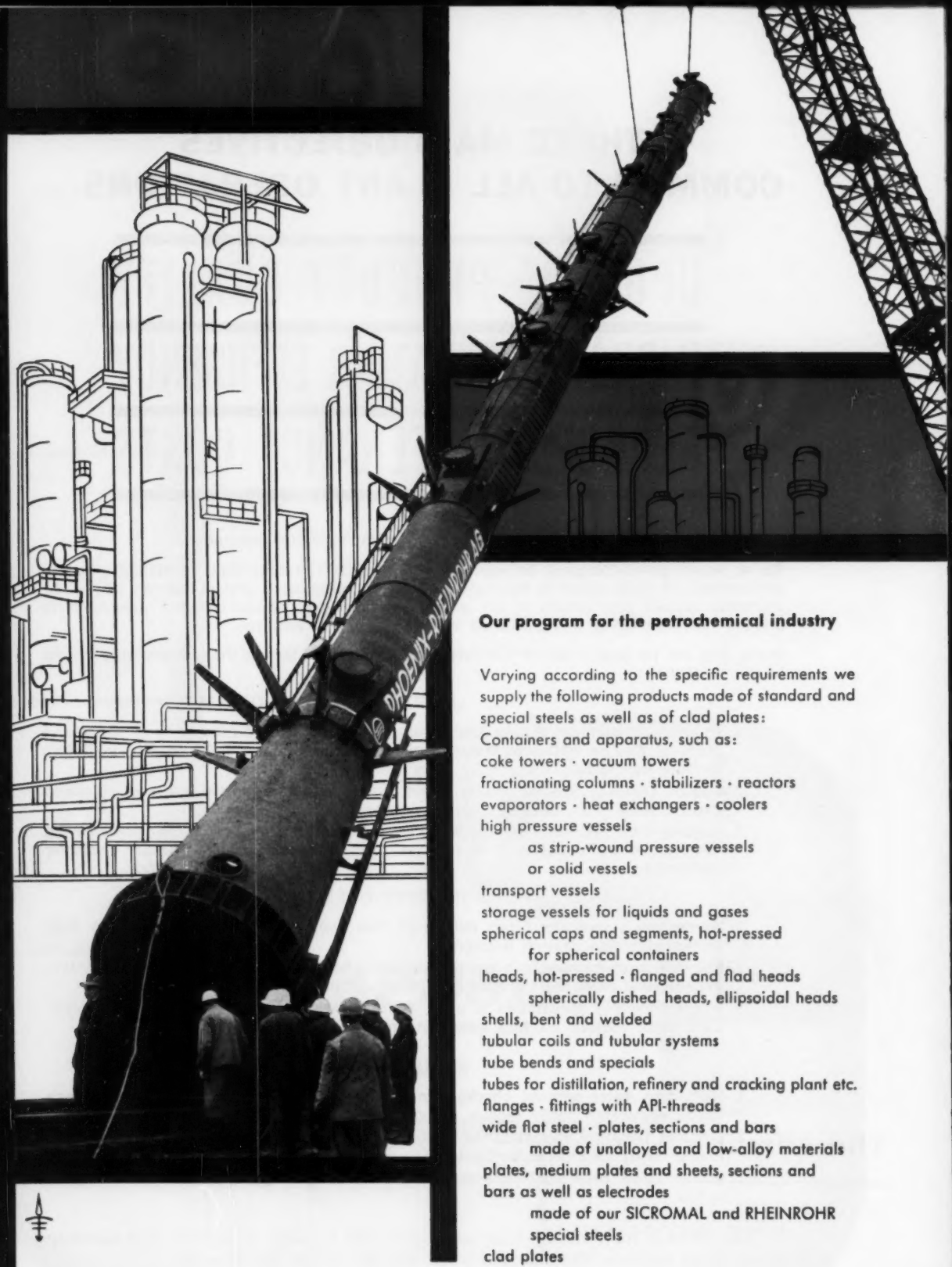
For more data on advertised products, use cards, last page.



Our program for the petrochemical industry

Varying according to the specific requirements we supply the following products made of standard and special steels as well as of clad plates:
Containers and apparatus, such as:
coke towers · vacuum towers
fractionating columns · stabilizers · reactors
evaporators · heat exchangers · coolers
high pressure vessels
as strip-wound pressure vessels
or solid vessels
transport vessels
storage vessels for liquids and gases
spherical caps and segments, hot-pressed
for spherical containers
heads, hot-pressed · flanged and flad heads
spherically dished heads, ellipsoidal heads
shells, bent and welded
tubular coils and tubular systems
tube bends and specials
tubes for distillation, refinery and cracking plant etc.
flanges · fittings with API-threads
wide flat steel · plates, sections and bars
made of unalloyed and low-alloy materials
plates, medium plates and sheets, sections and bars as well as electrodes
made of our SICROMAL and RHEINROHR special steels
clad plates

PHOENIX-RHEINROHR AG
VEREINIGTE HÜTTEN- UND RÖHRENWERKE DÜSSELDORF
GERMANY

The oilman: Wizard with a wave – Even styling a fair lady's hair depends on petroleum – in the form of oil-based chemicals for permanent wave lotions. Petroleum in one or another of its many guises touches almost every aspect of our day-to-day life. That's why you, the oilman, are so important to America. You're helping, with better products and services, to build a pleasanter, more convenient world for us all. So if you hear anyone speak against oil, tell him you're proud to be an oilman – making possible new uses for one of the world's most versatile natural resources.

SHELL OIL COMPANY

For more data on advertised products, use cards, last page.

It's new and exclusive...

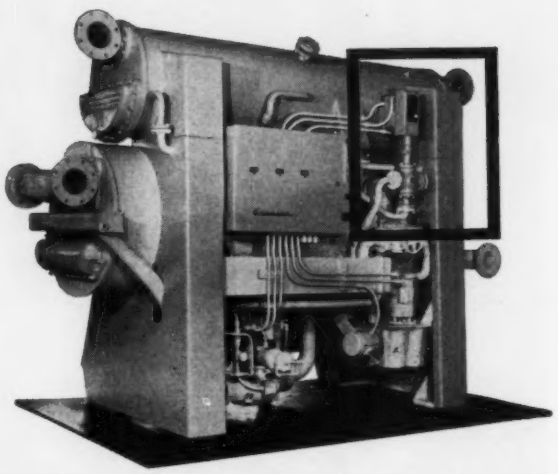
CARRIER SOLUTION CAPACITY CONTROL

with Automatic Absorption Refrigeration cuts operating costs to an all-time low!

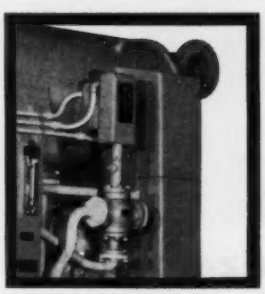
Through lower steam consumption per ton of refrigeration when working at partial load, Carrier Solution Capacity Control cuts operating costs. Since refrigeration equipment seldom works continuously at full load, the savings it effects can be substantial. With it, full advantage may be taken of the lowest possible steam rates. Results: Maximum economy and peak efficiency.

Two other advantages of Solution Capacity Control: (1) Steam pressure always remains constant. There's no need for manual or costly automatic steam control valves. (2) In addition to reducing steam consumption at partial loads, this Carrier development lowers the temperature of the condenser water leaving the machine and also eliminates bleeding of air into the condensate system. Results: Longer life, reduced water treatment requirements and few shutdowns.

Available for either electronic or pneumatic operation, Solution Capacity Control is now standard on all Carrier Automatic Absorption Liquid Chilling Packages. It can be installed with only minor adaptation at job-site on existing Carrier units. A Carrier representative will be glad to give you complete information about it. Write Carrier Air Conditioning Company, Syracuse 1, New York. In Canada: Carrier Air Conditioning Ltd., Toronto 14.



For air conditioning or process cooling, the Carrier Automatic Absorption Liquid Chiller uses low-pressure steam, high-temperature hot water or other hot liquids to produce refrigeration. Capacities: 50 to 1000 tons.



Solution Capacity Control System precisely controls machine output by reconcentrating only enough lithium bromide solution to handle the refrigeration load. When operating at partial capacity, the excess portion of full load solution is bypassed through the capacity control valve – positioned automatically in response to chilled water demands. Capacity control avoids all the additional heat loss which would accompany the unnecessary heating and cooling of the solution.

Carrier Air Conditioning Company

POWELL MAKES IT A SIMPLE MATTER

To find the right valve, for the petroleum industry, just call Powell. It's that simple, since Powell offers industry's most complete selection of valves in bronze, iron, steel, and alloys to control the flow of water, oil, gas, air, steam and corrosive fluids.

What's more, you don't have to wonder about Powell performance. It's built-in through sound engineering, development, materials and workmanship.

So, remember, finding the right valve can be a simple matter when you specify Powell Valves. For further information, call your nearby Powell Valve Distributor (there's one in every major city), or write us direct.

115th year of manufacturing industrial valves for the free world

POWELL PETROLEUM **VALVES**

THE WM. POWELL COMPANY CINCINNATI 22, OHIO

For more data on advertised products, use cards, last page.

Another big day for W. R. Grace...in Chemicals

W. R. Grace & Co.'s Nitrogen Products Division is now producing another 60,000 tons per year of ammonia. The ribbons were cut... the valves were opened... the start-up buttons were pushed... the test runs have been completed. This process plant start-up marked the completion of Job 1250, another Chemico plant put into operation on time at above rated capacity. For W. R. Grace & Co. it was, understandably, a big day. Those familiar with Chemico's record of process engineering achievements expected no less. They were not at all surprised when this new Grace ammonia plant was placed on stream without difficulty or delay.

Chemico experience pays off for the client in many ways... in more efficient designs, lower operating costs, ease of start-up and most important... lower product costs. If your company is considering the construction of new or expanded process facilities, Chemico engineers would be pleased to discuss your plans with you. Address all inquiries to: Chemico Sales Department

CHEMICO

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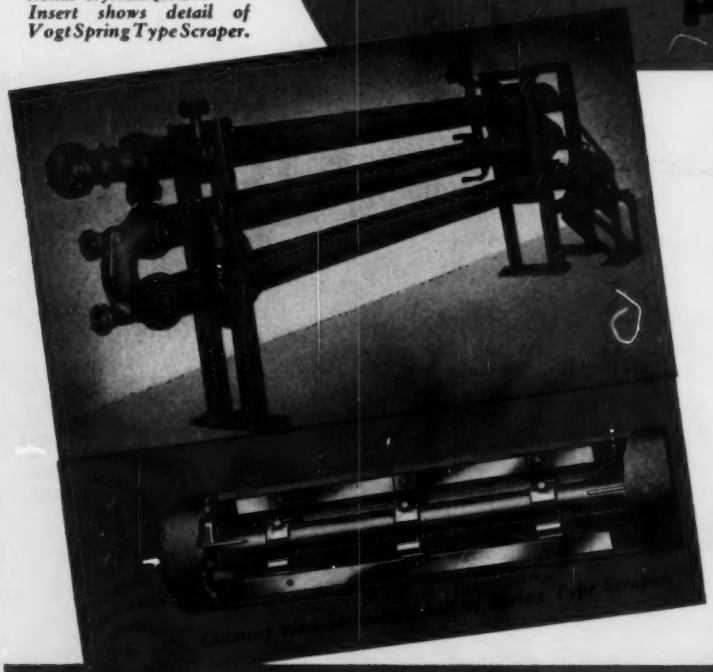
Vogt

SCRAPED SURFACE EXCHANGERS *Solve* those Special Heat Transfer and Crystallization Problems . . .

BELOW: *A scraped surface unit for production of Para-Xylene by fractional crystallization. Insert shows detail of Vogt Spring Type Scraper.*



. . . *And Here's How:*

1. Rotating scraper action continuously sweeps surfaces clean even while processing highly adhesive materials.
2. Uniform rate of heat transfer keeps crystallization under control and discharges crystals as a slurry.
3. Product is thoroughly mixed by scraper blades as it flows.
4. Closed, pressure-type system permits use of flammable, volatile and expensive solvents with complete safety and no solvent loss.
5. Units fabricated from a broad range of materials to suit process stream characteristics.

Write for Literature. Address Dept. 24A-XPR

Listed here is a wide variety of materials which have been successfully processed with Vogt Scraped Surface Exchangers in the chemical, petro-chemical, petroleum and related industries.

Benzene Hexachloride
Caustic Soda
Caustic Potash
Clay
Cylinder Stock
Para-Dichlorbenzene
Fatty Acid Solutions
Fish Oil
Linseed Oil
Naphthalene
Paratone & Solids
Phenolic Resins
Polyester Liquid
Pressed Distillate
Reduced Petroleum
Waxy Oil-Solvent Mix
Soybean Oil
Sperm Oil
Sugar Syrup
Sulfur-Oil Mix
Sulphate Solution
Tall Oil-Naphtha-Sulfuric Acid Solutions
Tetrachloro Benzene
Viscose
Wax Slurry
Para-Xylene

HENRY VOGT MACHINE CO.
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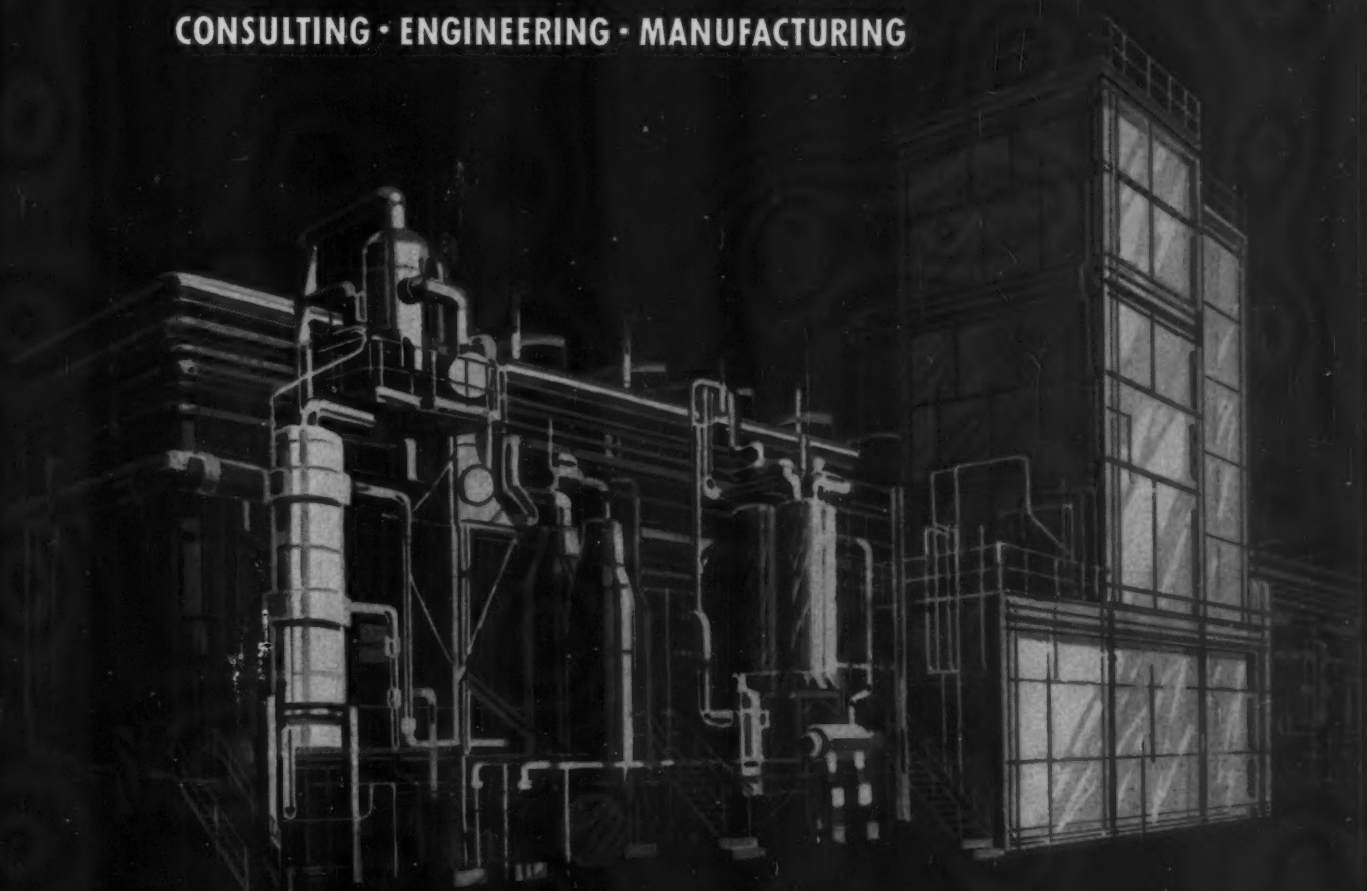
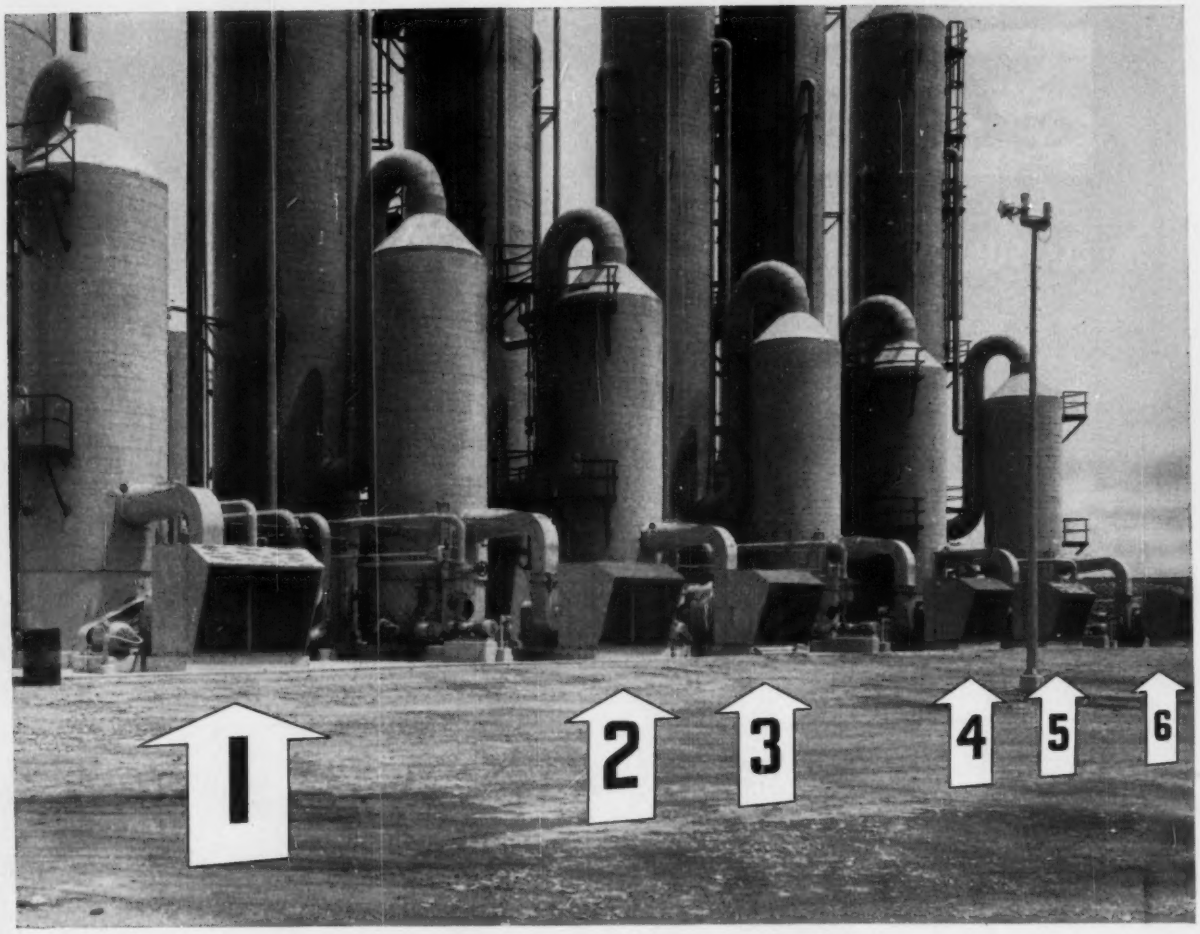


Plants for the decomposition of cracking gases or other gas-mixtures occuring in the chemical industry, in particular for the production of pure hydrogen, ammonia synthesis gas, methanol synthesis gas, purest ethylene, pure methane, pure propylene, benzene and other hydrocarbons, acetylene, pure carbon dioxyde.

Tonnage oxygen plants for the decomposition of air and in particular for the extraction of high purity oxygen and nitrogen in gaseous or liquid states, as single products or with simultaneous production of both gases, for chemical and metallurgical purposes.

GESELLSCHAFT FÜR LINDE'S EISMASCHINEN AKTIENGESELLSCHAFT

ZWEIGNIEDERLASSUNG HOLLRIEGELSKREUTH · HOLLRIEGELSKREUTH NEAR MUNICH, WESTERN GERMANY



Six "mouths" to feed... each protected by AAF

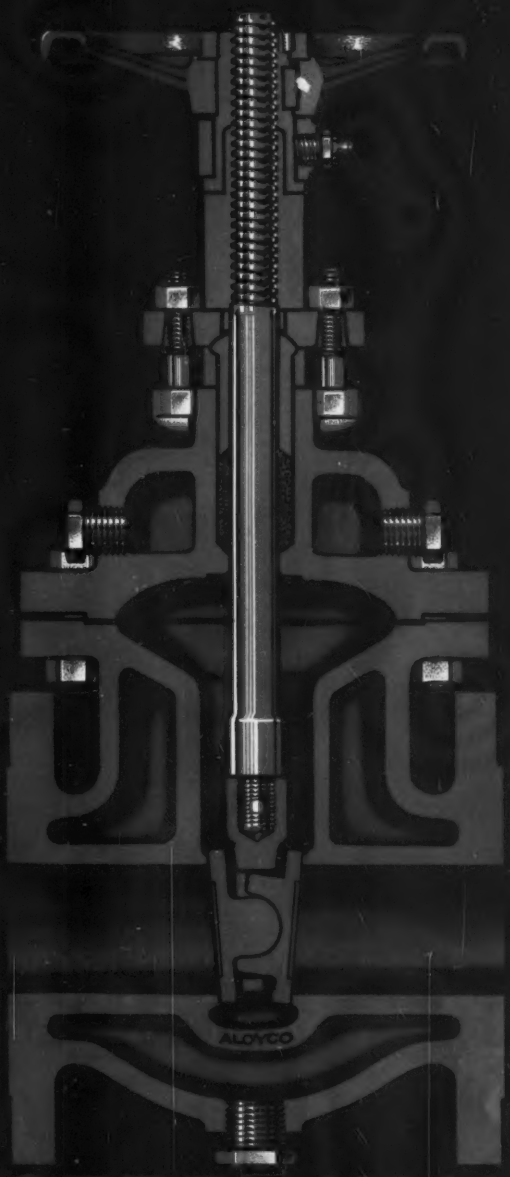
These giant heat-recovery towers depend on a constant "diet" of *clean air* for efficient, uninterrupted operation. They are part of Transwestern Pipeline Company's new gas-treating plant at Fort Stockton, Texas, where CO_2 is extracted from natural gas.

Banks of AAF PL-24 dry-type unit filters provide the right degree of air cleaning for each tower —day in, day out. The PL-24 is a rugged, all-metal unit which utilizes inexpensive disposable media. The filter's pleated design provides 28½ sq. ft. of media in a face dimension of 2 feet square and a depth of only 8 inches. Initial cost of the PL-24 is low. Replacement media comes in rolls and can be quickly and easily installed in the pleated filter cell at a replacement cost which can be less than 50¢ per unit, depending on the type of media used.

Whether your operation is in a desert, arctic, or temperate region — whether your application is process, pumping, or power — AAF has air filtration equipment *engineered* to match your requirements!

Get complete information from your nearby AAF representative; or write Mr. Robert Moore, American Air Filter Company, Inc., 452 Central Avenue, Louisville, Kentucky.

AAF American Air Filter
BETTER AIR IS OUR BUSINESS



Over thirty years' research devoted exclusively to...

STAINLESS STEEL VALVES

Aloyco's specialized research — in the field and in the lab — brings you a wealth of metallurgical information for successfully solving your corrosives handling problems.

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Isn't your surest source of supply the one company with research, manufacturing and sales all devoted to Stainless Steel Valves exclusively?

Longer Lasting
ALOYCO
VALVES
1ST IN CORROSIVE SERVICE

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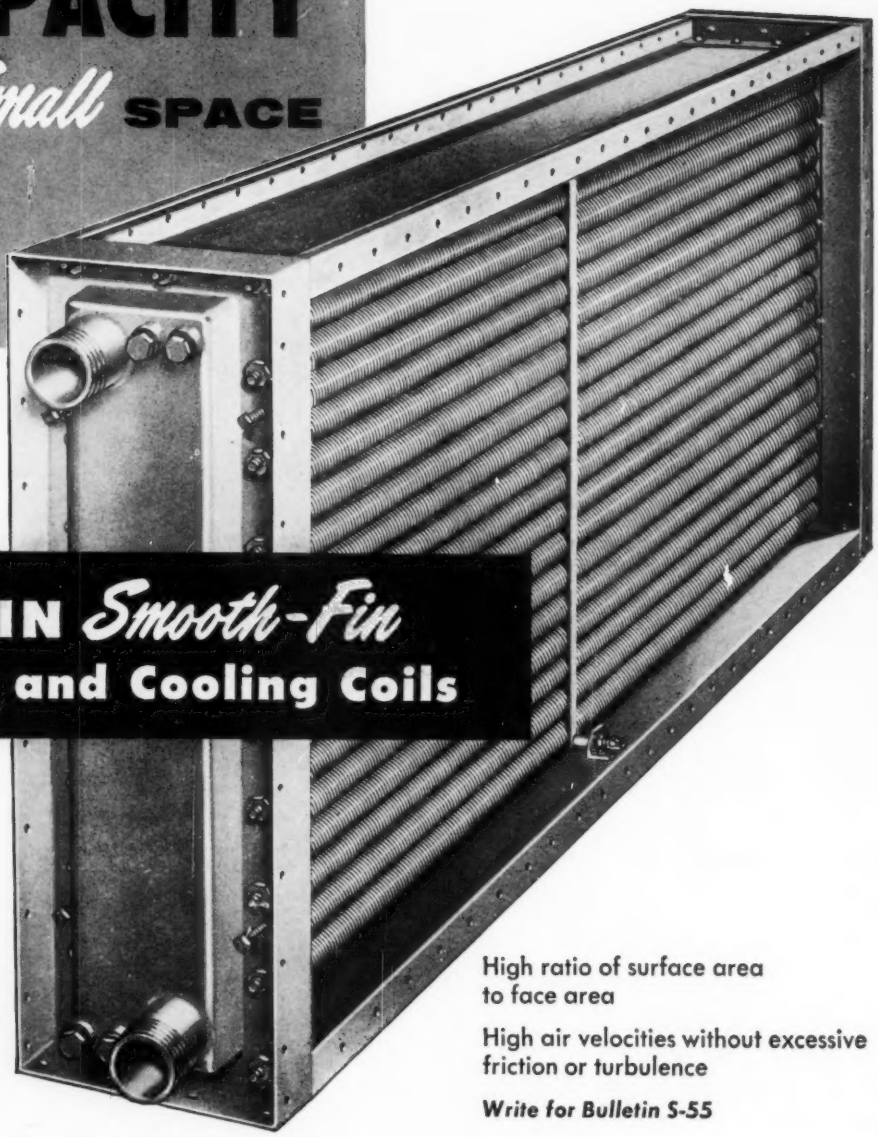
BIG CAPACITY IN *Small* SPACE



AEROFIN *Smooth-Fin* Heating and Cooling Coils

High ratio of surface area to face area

High air velocities without excessive friction or turbulence

Write for Bulletin S-55

AEROFIN CORPORATION

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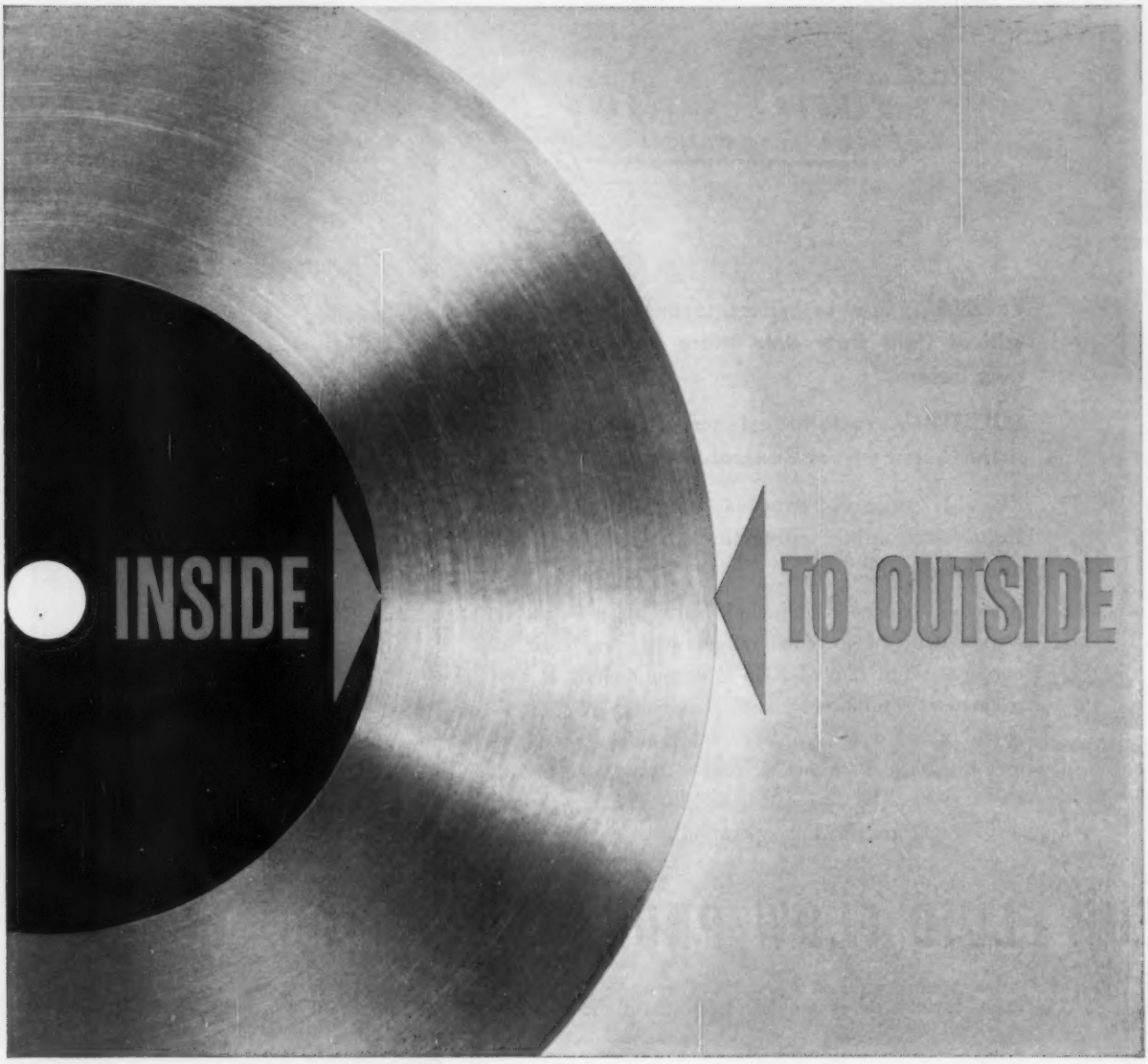
Aerofin is sold only by manufacturers of fan system apparatus. List on request.

ENGINEERING OFFICES IN PRINCIPAL CITIES



maximum tube life per dollar—When you buy Timken® seamless steel pressure tubing, you receive fine forged quality that is uniform from heat to heat, tube to tube, order to order. We target it to your end use. And our metallurgists draw from a background of over 40 years' experience to help you select the one tube that will give you maximum tube life per dollar.

Timken seamless steel tubing is available in carbon, alloy and stainless grades, up to 11" O.D. and 3¼" wall. And there's a Timken seamless steel pressure tube to meet practically any combination of temperature, pressure or corrosion. For help that assures your selection of the one tube that will be most economical and perform best for you, call in Timken Company metallurgists. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

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TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

FOR QUALITY... PRODUCTIVITY ...PROFIT

INSTRUMENTATION FOR AUTOMATION

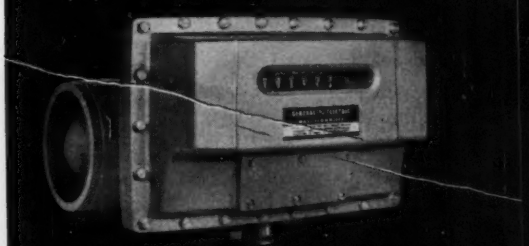
PROBLEM: how to collect, record and transmit critical fluid flow data more *accurately* than ever before.

SOLUTION: custom-designed flow measurement systems from General Electric.

RESULT: reliable process control, simplified fluid accounting, precision batch blending and loading.

System instrumentation includes: true mass flowmeter, available in 13 standard ranges ■ null balance recorders, a full line of strip and round-chart ■ new telemetering equipment, analog and digital.

In addition, ticket printers and totalizing counters are available for visual digital display and pre-set counters may be added to provide precision control in blending and loading operations.



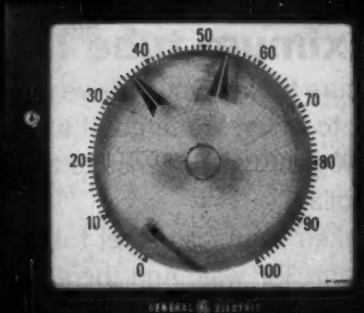
Mass Flowmeter measures fluid flow directly in pounds, eliminates volume-to-mass conversion. ±1% accuracy unaffected by change in pressure, density, temperature, viscosity, flow rate. 13 standard ranges now available.

FOR FLUID FLOW PROCESS:

HIGH ACCURACY

In a variety of system applications, these General Electric instruments cut operating costs and boost plant production . . . through *simplified* and *more accurate* measurement. No wonder they've been specified by process engineers throughout the world. *Performance-proved . . . on the line!*

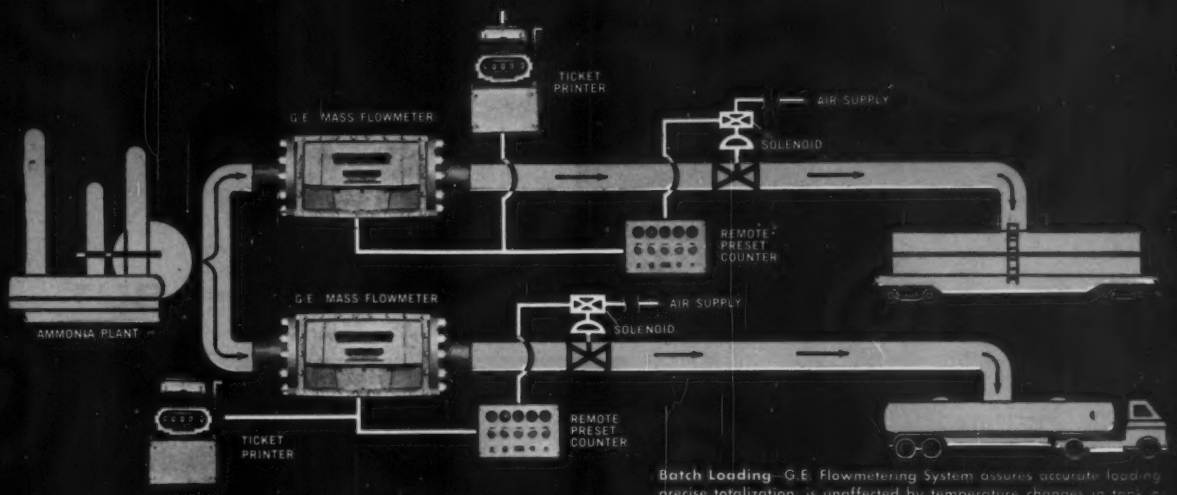
For complete information, contact your nearby General Electric sales office or write Section 599-08, General Electric Co., Schenectady 5, N. Y. for the following bulletins: GEA-6925, Mass Flowmeter; GEA-6887, Null Balance Recorders; GEA-7163, Telemetering Systems. In Canada, contact Canadian G.E. Co. Ltd., 940 Lansdowne Ave., Toronto 4, Ontario. Outside the U.S. and Canada, contact International G.E. Co., 150 E. 42nd St., New York 14, N. Y.



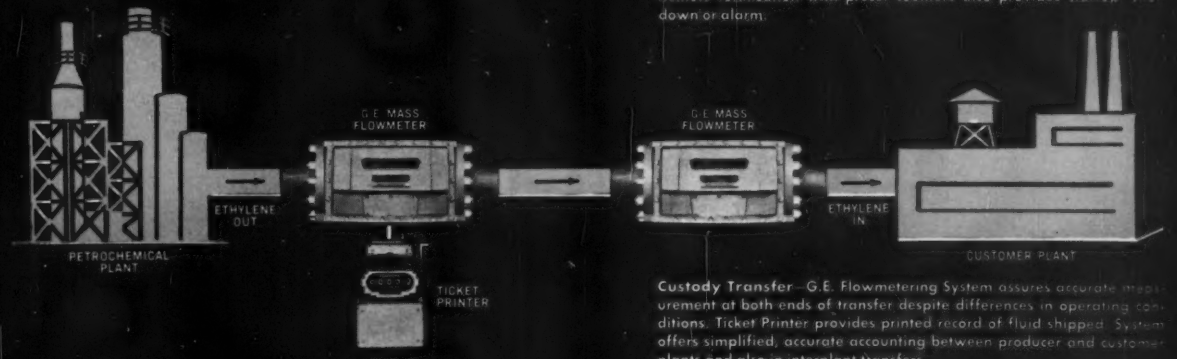
General Electric Null Balance Recorders feature: silicon diode reference voltage source for operational reliability; varied control forms for versatile applications; components mounted on swing-out panel to simplify routine maintenance. Full line includes multipoint, single and two-pen—strip or round-chart models.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

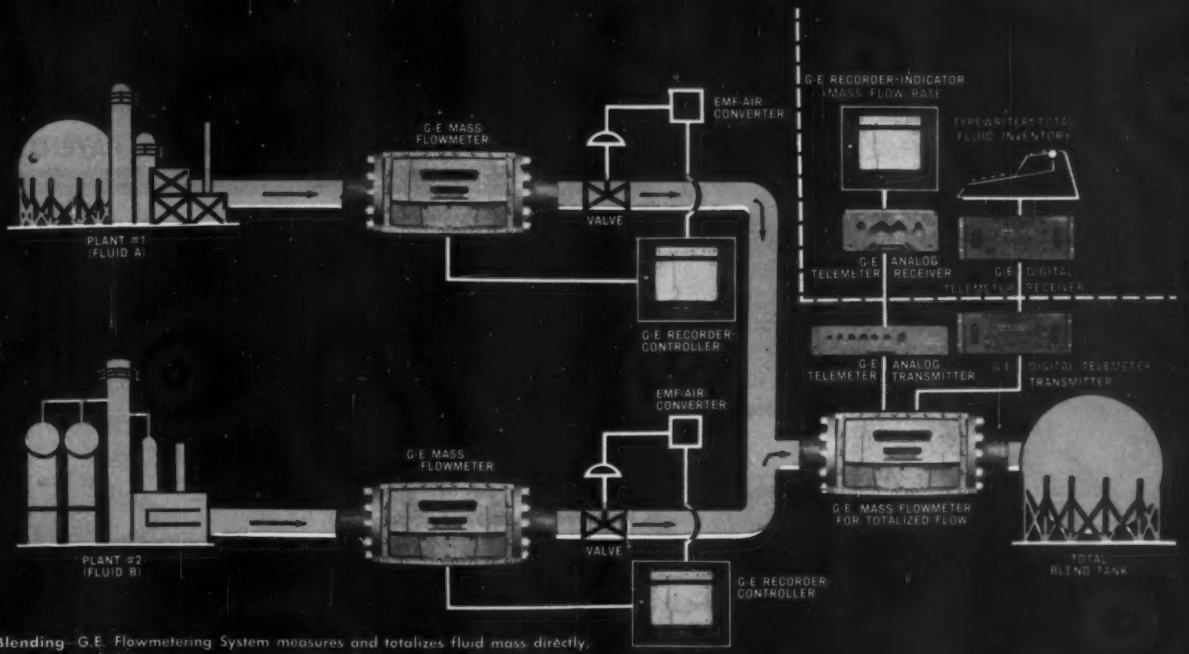


Batch Loading—G.E. Flowmetering System assures accurate loading, precise totalization, is unaffected by temperature changes in tank or pipe. Meter measures different fluids with no calibration changes. Remote totalization with preset counters also provides startup, shutdown or alarm.

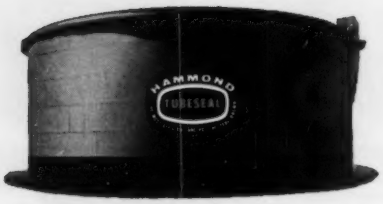


Custody Transfer—G.E. Flowmetering System assures accurate measurement at both ends of transfer despite differences in operating conditions. Ticket Printer provides printed record of fluid shipped. System offers simplified, accurate accounting between producer and customer plants and also in interplant transfers.

MEASUREMENT SYSTEMS FROM GENERAL ELECTRIC

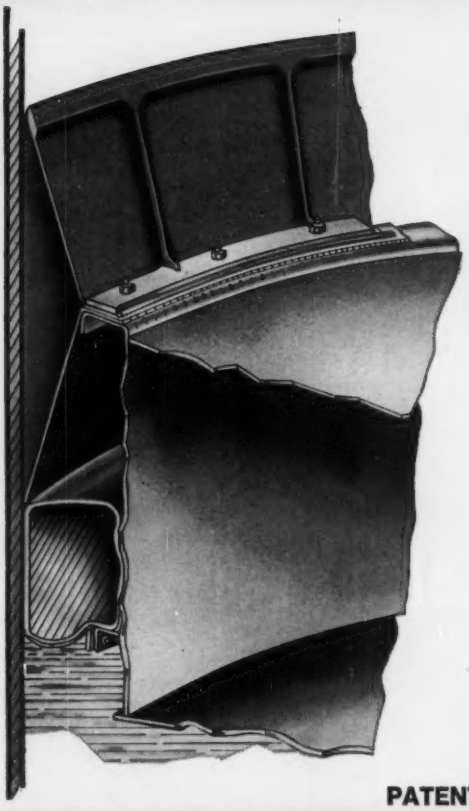


Fluid Blending—G.E. Flowmetering System measures and totalizes fluid mass directly, eliminates laborious volume-to-mass conversions. Predetermining counters assure simplicity and accuracy in blending operations. Data is instantly telemetered to central locations by new G-E Telemetering. Typical blends are refrigerants, solvents and special naphthas.



ALL FLOATING ROOF TANKS ARE FULLY EQUIPPED, **BUT...**

Only Tubeseal Has Lightning-Proof, Electro-Conductive Weather Shield



PATENTED

Tubeseal electro-conductive weather shields are an *exclusive tried and proved development.* They provide positive protection against lightning-caused rim fires. ■ How? By maintaining a *continuous* grounding bond between roof deck and shell—concentration of static charges is impossible. There has *never* been a lightning fire where any of the many hundreds of Tubeseal System Floating Roof Tanks are installed throughout the world—they're "lightning proof." ■ This is scientific and safe storage protection for the entire range of volatile products. Tubeseals can be installed on any of your tanks—new, old, riveted, or welded. You owe it to the future safety of your conservation facilities to investigate. Send for the Tubeseal Bulletin now—it could be important.

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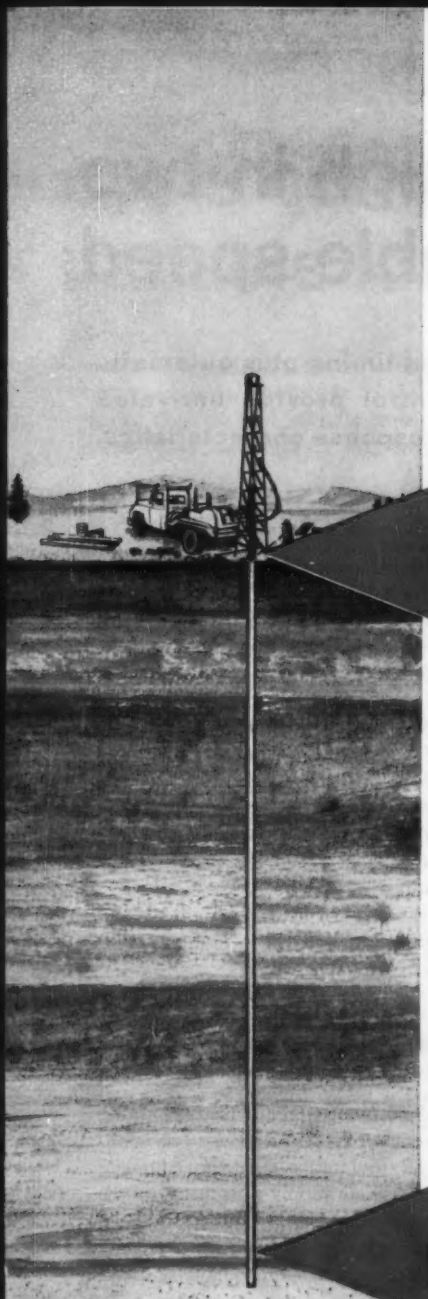
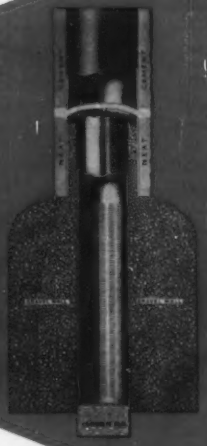


Layne
SINCE 1882

has the only complete service that means Water

Layne Vertical Turbine Pumps are designed, engineered and manufactured by Layne in Memphis, Tennessee and nowhere else. Because pumping needs vary, there is a Layne pump for every pumping requirement—from 30 to 100,000 G.P.M. in sizes from 4 to 42 inches. Layne Pumps include Deep Well and Short Coupled (oil or water lubricated), Propeller, Mixed Flow, Regular and "In-Line" Submersible. For additional information write for bulletins 200-oil lubricated or 201-water lubricated.



The Layne Gravel Wall Well is an example of Layne experience, engineering and research. This gravel packing and 134 shutter screen employment affords larger screen openings, reduced friction, reduced draw down and pumping head. It increases specific capacity and makes for more effective retention of native sands. For additional information write for bulletin 900.

From top to bottom, you can depend on Layne for the most complete water service in the industry. This complete service provides undivided responsibility for the delivery of water . . . of the quality and in the quantity required. Over 75 years of *growing* service gives the skill and technical know-how which makes Layne First in the field of water. For additional information write for bulletin 10.

LAYNE OFFERS COMPLETE WATER SERVICE:

Initial Surveys • explorations • recommendations • site selection • foundation and soil-sampling • well drilling • well casing and screen • pump design, manufacture and installation • construction of water systems • maintenance and service • chemical treatment of water wells • water treatment—all backed by Layne Research.

Layne services do not replace, but coordinate with the services of consulting, plant and city engineers.

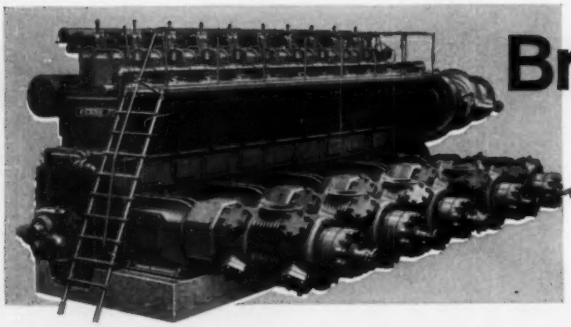
Layne SINCE 1882 COMPLETE WATER SERVICE

LAYNE & BOWLER, INC., MEMPHIS

General Offices and Factory, Memphis 8, Tenn.

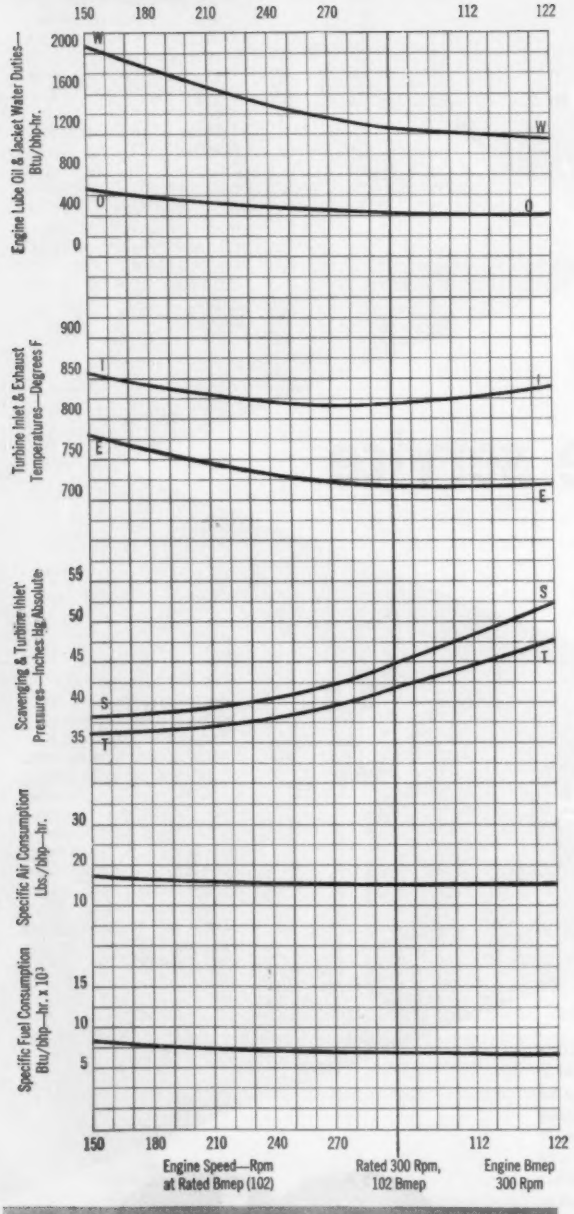
LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

SALES REPRESENTATIVES IN MAJOR CITIES



Breakthrough in two variable speed,

Automatic ignition timing plus automatic turbocharger control provide unrivaled speed, load and response characteristics.


150 180 210 240 270 112 122
Engine Lube Oil & Jacket Water Duties—Btu/bhp-hr.
2000 1600 1200 800 400 0
W
Q
Turbine Inlet & Exhaust Temperatures—Degrees F
900 850 800 750 700
I
E
Scavenging & Turbine Inlet Pressures—Inches Hg Absolute
55 50 45 40 35
S
T
Specific Air Consumption Lbs./bhp—hr.
30 20 10
Specific Fuel Consumption Btu/bhp—hr. x 10³
15 10 5
150 180 210 240 270 112 122
Engine Speed—Rpm at Rated Bmep (102)
Rated 300 Rpm, 102 Bmep
Engine Bmep 300 Rpm

Performance curve of Clark Model TLA turbocharged, 2-cycle, gas-engine-driven compressor. Unit features 17"x19" bore and stroke. Rated speed is 300 rpm. Rated bmep is 102 psi. Note the remarkable parallel between the fuel consumption and specific air consumption curves.

Q. What makes two cycle engines so well suited for variable-speed, variable-load applications?

A. It has long been traditional to consider two cycle engines as good prime movers for applications where power and speed are maintained close to 100% of rated load and speed. This may have been true a number of years ago when two cycle engines were single and twin horizontal designs. But the situation began to change with the introduction of vertical, multicylinder machines with direct fuel injection. Subsequent addition of constant pressure turbocharging and automatic ignition timing control have made two cycle performance equal or superior to four cycle engines in acceleration and in response to load or speed changes. Regardless of how fast the load or speed changes, the two cycle engine is able to adjust more rapidly because it fires twice as frequently. As a result the actual amount of load change between successive firings is cut in half, all other conditions being equal.

Q. Why has turbocharging caused such a vast improvement in two cycle engines?

A. The Clark system of constant pressure turbocharging permits variation of scavenging air flow with load to maintain relatively uniform air/fuel ratios over the complete operating range. This variable air supply plus maintenance of optimum ignition timing enables Clark engines to achieve excellent performance from substantial temporary overloads at rated speed down to the usually recommended 50% speed at constant torque.

Q. Why is constant pressure turbocharging so effective?

A. In general, all turbocharged engines are arranged to achieve best efficiency and fuel consumption at a particular design point—usually rated load. The Clark system of constant pressure turbocharging, however, is inherently capable of maintaining optimum efficiency not only at design point, but over an extremely broad operating range as well. The reason: *Clark turbocharging provides a flexible supply of combustion air that varies in direct proportion to load.* It does not depend on pulses of exhaust gas or on engine driven blowers, hence is free to provide the exact amount of air demanded by the engine. At light loads, there is neither a fall-off in performance nor any "lean out" problem arising from too much air. With increased loads, the turbocharger is able to pump increasingly more dense scavenging air into the power cylinders. There is no element in the

cycle compressor performance for variable load applications

system to impede or interfere with the performance of the turbocharger as it responds to the higher power requirements. Thus the fuel/air ratio remains constant through the entire operating range for best engine performance.

Q. Are there other important advantages of the Clark Constant Pressure Turbocharging system?

A. Yes. In addition to efficient combustion, the large amounts of available scavenging air have a cooling effect on the cylinder walls, cylinder heads and piston heads. Possibility of detonation is minimized, better lubrication is assured, and the temperatures of the exhaust gases are controlled as they enter the turbocharger. The cooling effect of the excess scavenging air is especially advantageous at high ambient temperatures. It lowers overall cooling duty and enables the Clark intercoolers to provide adequate scavenging air cooling. There is no need to resort to evaporative cooling of air or other special means of preventing detonation and cylinder wear.

Q. How does Clark achieve such good low speed lugging characteristics?

A. With Clark turbocharged, two cycle engines, compressor capacity can be most easily and efficiently varied by adjusting speed while maintaining at or near rated load torque. *The engine-driven compressor is then operating at rated load all the time, at which condition it functions most efficiently.* The exceptional low speed lugging characteristics are due primarily to frequent power impulses that reduce cyclic speed variation. At low speeds, cyclic speed variation is always accentuated because flywheel inertia is reduced in proportion to the square of speed reduction, and power impulses become less frequent with respect to time. Thus the two cycle engine has a great advantage because each cylinder fires every revolution.

Q. How do Clark two-cycle engines perform under overload conditions?

A. A glance at the chart showing actual test data taken from a Clark turbocharged Model TLA gas-engine-driven compressor demonstrates graphically that the fuel consumption curve is remarkably flat over a wide range. When operating as high as 20% overload under emergency conditions, Clark engines actually burn *less* fuel per bhp than at rated load. Even more important is the manner in which the specific air and specific fuel consumption curves parallel each other perfectly over the entire range. This illustrates the inherent advantage of Clark "true" turbocharging system. Once the engine is started and the turbine is self-sustaining, the turbocharger adjusts itself freely and almost instantaneously to the demands of the engine.

Q. How does ignition timing control improve operating performance?

A. There are two conditions in which ignition timing control is used with the Clark system: At startup and at reduced speeds. During the starting cycle, the timing control automatically adjusts the ignition to increase the flow of heat to the turbocharger. This shortens startup time and substantially reduces consumption of starting air.

At reduced speeds (i.e. from 50% to 80% rated speed), the ignition is automatically regulated to maintain optimum ignition timing consistent with the rate of pressure rise in the cylinder with respect to time. Thus the peak pressure is reached at or near top dead center and expansion of the burned gases takes place most effectively with less tendency to detonation.

Q. What is the net effect of combining turbocharging with two-cycle engines?

A. The user enjoys all the advantages of a two-cycle engine —simplicity, fewer moving parts, greater dependability— plus the advantage of turbocharging—more power in less space, better fuel economy, greater operating flexibility. Clark two-cycle gas-engine-driven compressors are very conservatively rated. Lower bmep eliminates the ignition difficulties and fouling tendencies common in higher rated machines. There are no large exhaust or intake valves to warp, pit or burn. Two-cycle design keeps continuous downward pressure on the power pistons, thereby eliminating oil "pumping." There is no piston ring blowby, the cause of sludging and crankcase oil dilution. The two-cycle engine is less sensitive to detonation under high ambient temperatures. Thus Clark design reduces costly maintenance and assures more profitable "uptime."

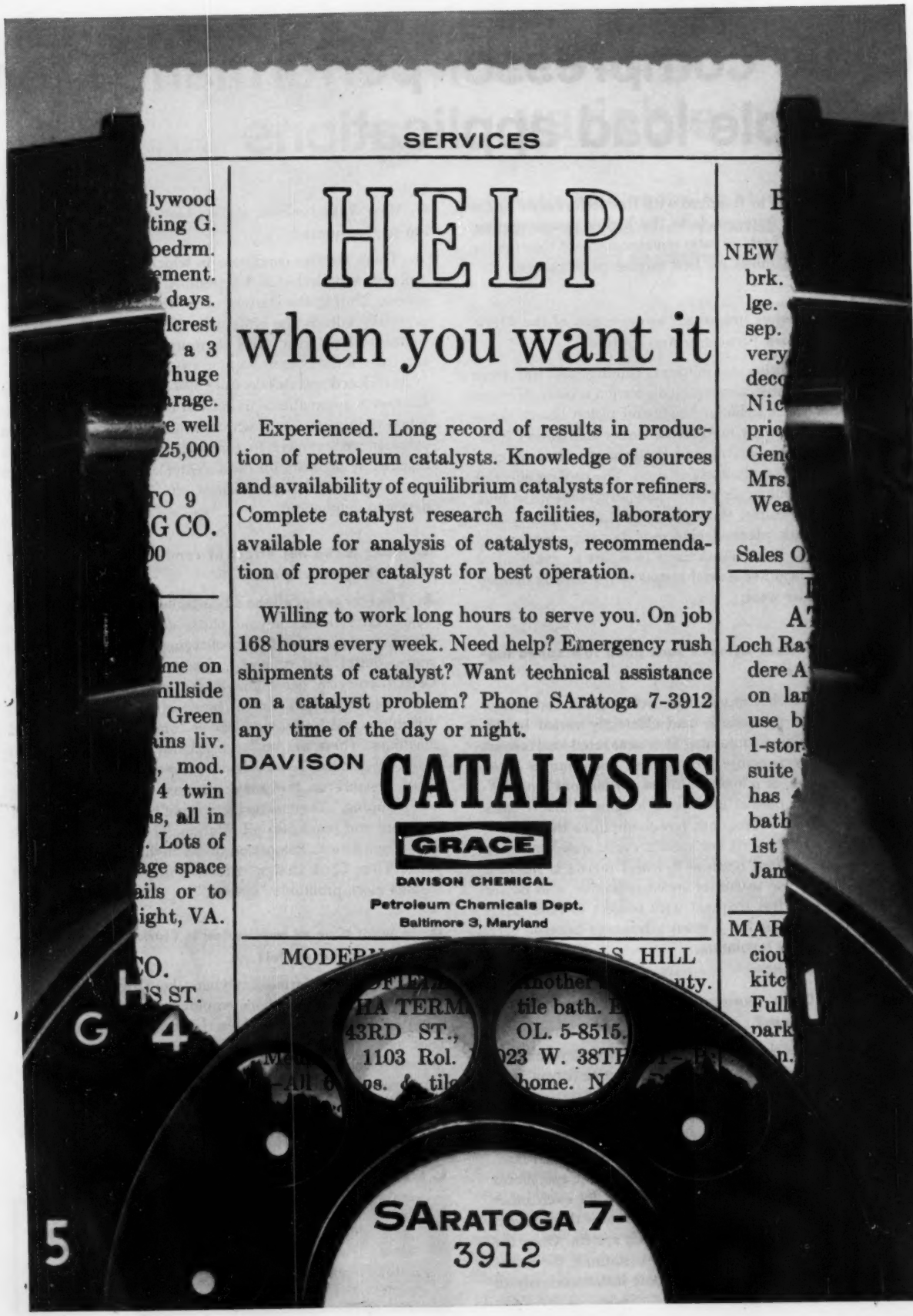
Q. In what type of application is Clark capacity variation with speed useful?

A. Pipeline gas transmission where there are few units in a station. Process applications employing gas engine drivers. Gas distribution boosters where the compressors are located near sales outlets. Manufactured gas compressors. Field gathering compressors where few units can be economically employed and wide variation in gas supply is expected.

For more details on how Clark variable-speed, variable-load performance can help you, contact your nearest Clark office or write to:

CLARK BROS. CO., OLEAN, N. Y.

For more data on advertised products, use cards, last page.



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Willing to work long hours to serve you. On job 168 hours every week. Need help? Emergency rush shipments of catalyst? Want technical assistance on a catalyst problem? Phone SAratoga 7-3912 any time of the day or night.

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SARATOGA 7-
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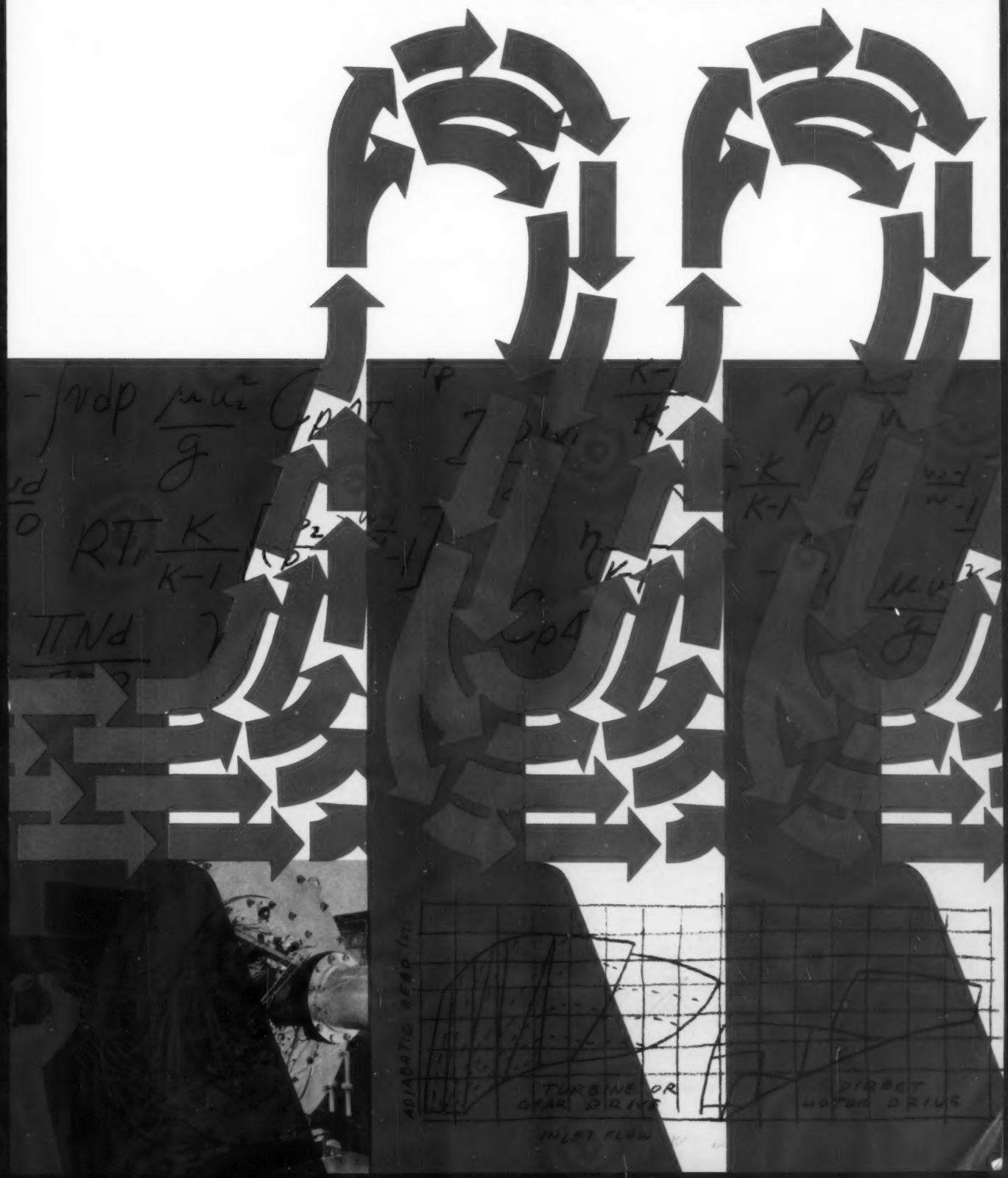
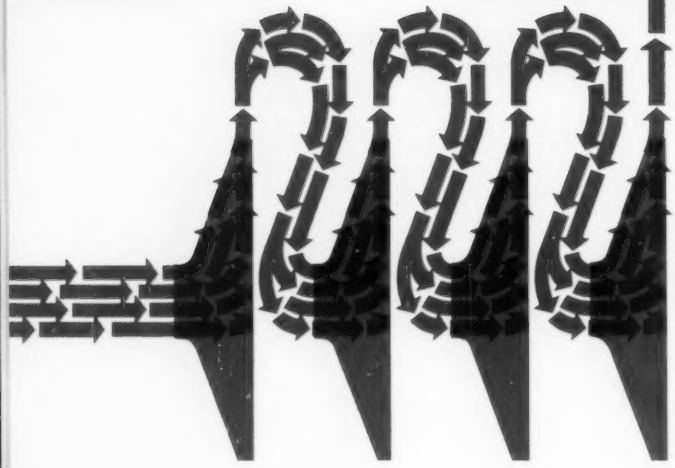
SOLID FOUNDATION FOR PROGRESS

Engineering Research is the backbone of Elliott developments in centrifugal compressor design. Persistently exploring new paths to broader application flexibility, better operating efficiency, increased reliability, Elliott compressor research engineers study aerodynamic, thermodynamic, mechanical, metallurgical and related subjects to improve and perfect the performance of Elliott compressors. **ELLIOTT COMPANY**





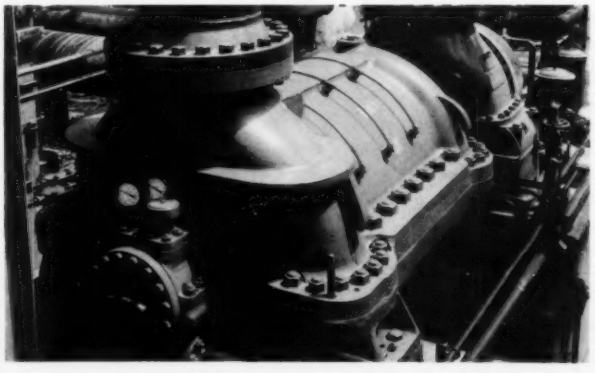
IS BEING DEVELOPED

HERE This is a part of the Elliott compressor development facility—a highly-sophisticated proving ground for new ideas.

With the research equipment pictured here, new compressor wheel designs, new diffuser and return channel patterns, new inlet and discharge geometry can be evaluated. A multiplicity of temperature and pressure probes report conditions at test stations from inlet to discharge. Compressor components under study can be operated as an open air system or as a closed loop.

The knowledge gained with this and other unique research facilities will assure continued advances in the design and application of Elliott compressors.

This is one of the Elliott machines now in service into which has been incorporated fundamental basic knowledge already gained through the use of the above facility.



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ELLIOTT THE MOST COMPLETE LINE OF INTEGRATED COMPRESSOR & DRIVER UNITS 500 cfm to 600,000 cfm

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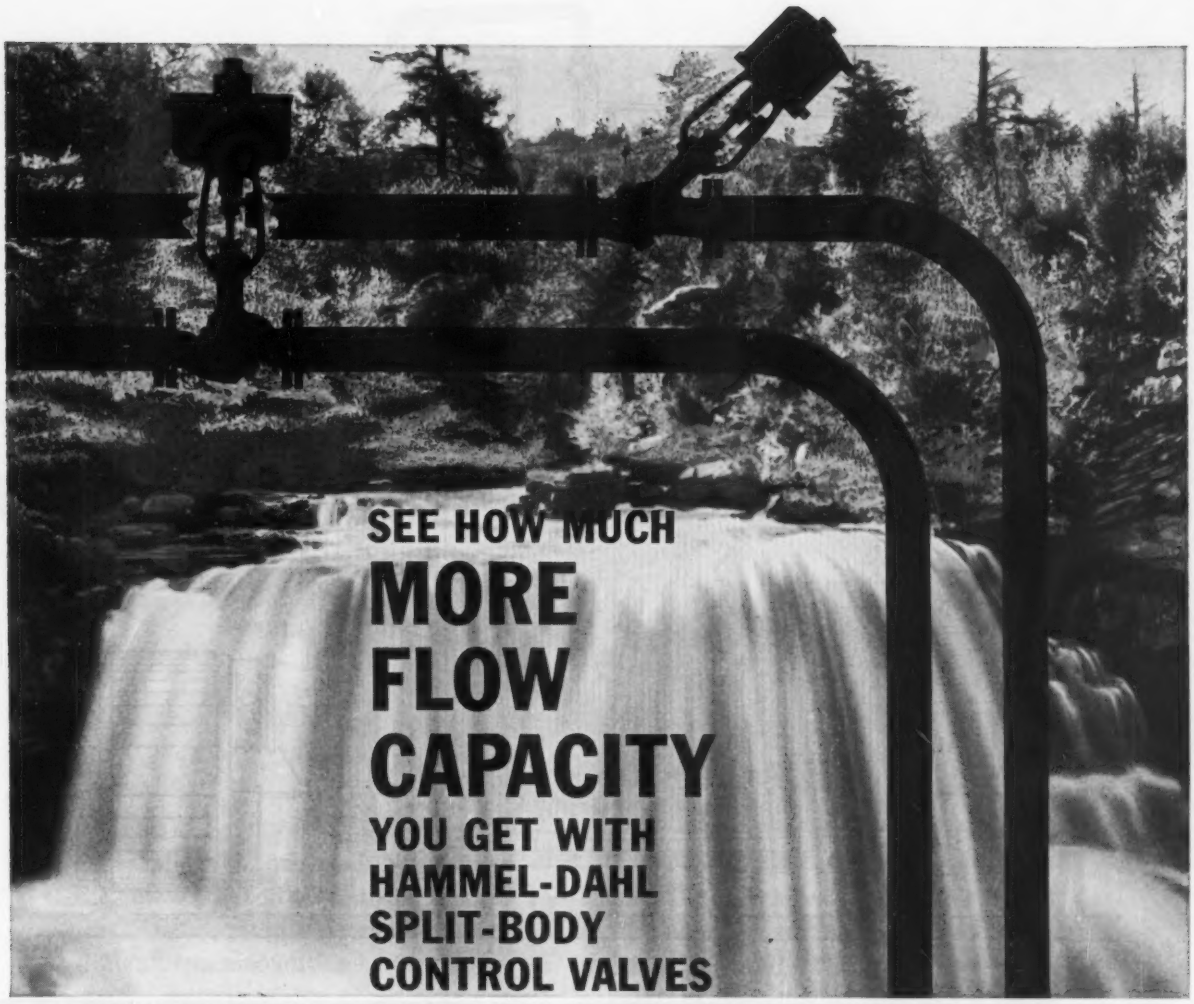


TABULATED Cv's PROVE:

Hammel-Dahl "S" Style Split-Bodies have significantly higher capacities than similar valves now available . . .

Where other valves don't quite measure up, get the capacity you need without a size increase!

Hammel-Dahl "Y" Style Split-Bodies feature a completely unimpeded flow pattern and set new standards for control valve Cv's . . .

With valves able to handle so much more flow, you can scale down your entire piping installation!

Valve Size	Average of Competitive Split-Body Valve Cv's	Hammel-Dahl "S" Style Cv's*	Hammel-Dahl "Y" Style Cv's*		Valve Size
			Throttling	On-Off	
1"	12	13	18	20	1"
1½"	26	33	50	60	1½"
2"	45	50	100	105	2"
3"	107	135	225	244	3"
4"	182	240	380	400	4"

*Flow capacity measurement procedure — Fluid Controls Institute Recommended Standard 58-2.

Such savings deserve investigation. Write for our latest Split-Body bulletin S-B 71.

Manufacturers of Control Valves and Allied Equipment

HAMMEL-DAHL DIVISION

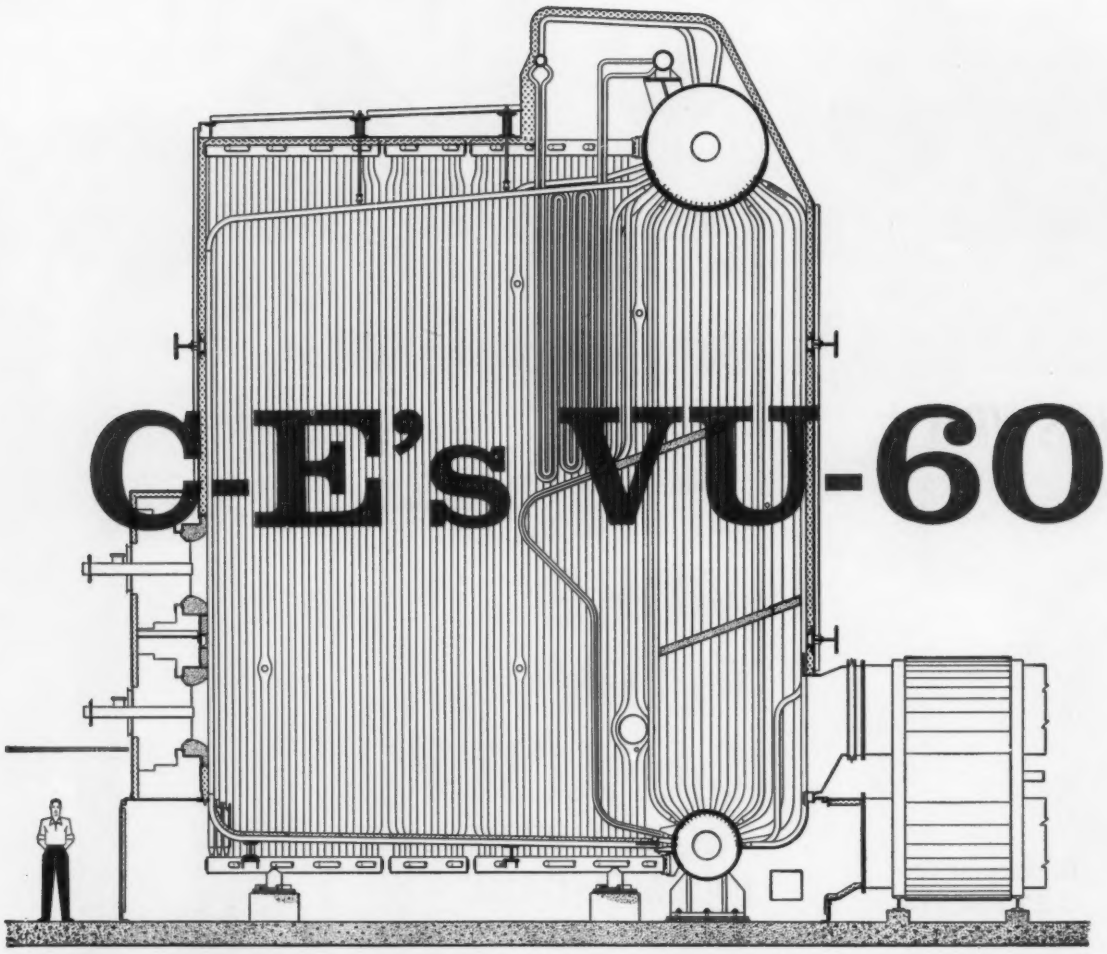
GENERAL CONTROLS CO.

WARWICK INDUSTRIAL PARK, WARWICK, RHODE ISLAND · STuart 1-6200

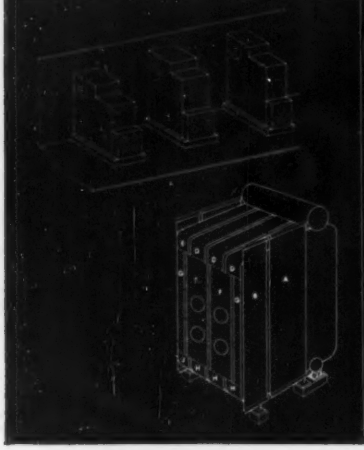
Factory Branch Offices or representatives in principal cities — United States and abroad.

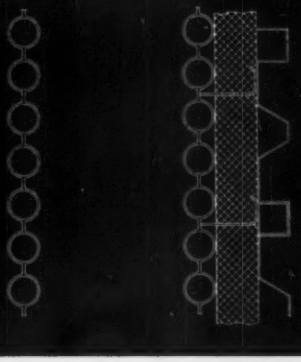
GEN 1-18

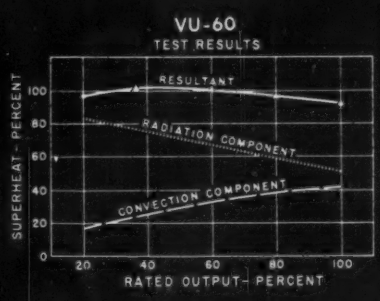
C-E's VU-60



SOME DESIGN HIGHLIGHTS OF THE VU-60







Modular increments allow assembly of custom designs from standardized components; boiler can be proportioned for best combustion, heat absorption, gas flow — even where space conditions are difficult.

Completely self-cased, the VU-60 is an all-welded pressure-tight envelope composed of modular panels of finned tubes; fewer field welds cut erection time.

Insulation and preformed lagging go directly over tube panels, thus reducing non-working weight per pound of steam generated.

Characteristic of Combustion's VU-60. This superheater curve indicates a temperature stability throughout entire load range.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER

GIVES YOU A CUSTOM-DESIGNED BOILER BASED ON STANDARDIZED MODULAR COMPONENTS

Because of its unique modular concept, C-E's new VU-60 offers unusual flexibility and can be designed to meet unusual or difficult space conditions.

VU-60 SPECIFICATIONS

Capacities:	100,000 to 250,000 lb per hr
Design pressures:	250, 500, 750, 1040 psi
Steam temperatures:	to 900F
Fuels:	Oil and/or gas
Firing:	Horizontal (front wall) or tangential
Size increments:	Depth-twelve Width-eight Height-three
Steam drum sizes:	Four

The VU-60 is a completely self-cased boiler. Finned tubes, shop-welded into modular panels, make up the exterior walls of the unit. The fins joining the panels are field-welded to make a pressure-tight envelope. Insulation is applied directly over these walls and is covered by pre-formed, field-installed metal lagging. The need for bulky or heavy nonworking structural members is kept to a minimum.

The VU-60 can be designed to meet your most exacting steam needs. It is easy to install, economical and dependable in operation, completely accessible and functional. Why not get full information on how this new concept can fulfill your specialized requirements?

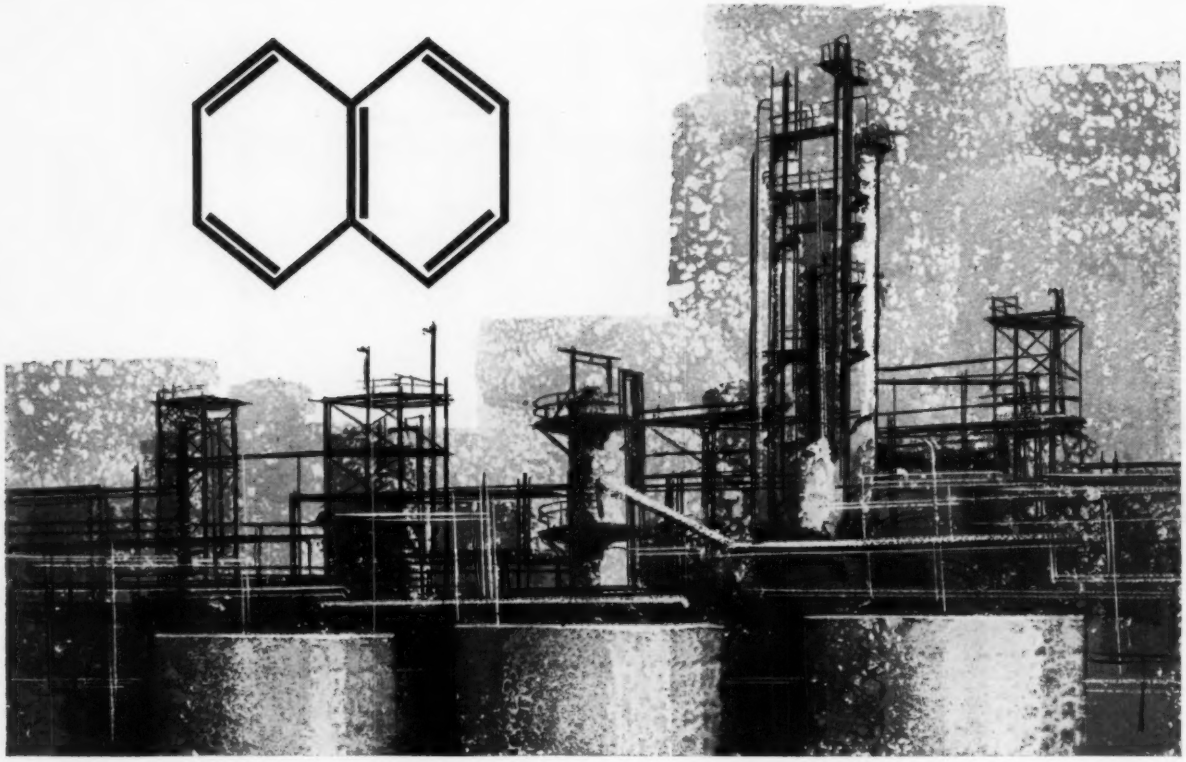
COMBUSTION **ENGINEERING**

General Offices: Windsor, Conn., New York Offices: 200 Madison Avenue, New York 16, N. Y.
Canada: Combustion Engineering-Superheater Ltd.

C-322

MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

For more data on advertised products, use cards, last page.



ENRICH NAPHTHALENE FEED STOCK WITH QO® FURFURAL

A high concentration of naphthalene precursors in the feed stock of a hydrodealkylation unit is desirable. A good way to obtain this maximum concentration is to separate the aromatic compounds from the feed stock by the use of furfural. An enriched feed stock will not only boost naphthalene production, but will also cut hydrogen consumption.

Furfural is a polar molecule and gives excellent separation of saturates from unsaturates in lube oils, gas oils, cycle stocks and naphthalene feed stocks. It is also effective in the separation of organic sulfur compounds or heavy metal complexes from petroleum fractions.

Furfural offers dual economy in its low price plus operational savings. In lube refining over 99.95% of the circulated furfural is recovered; the high thermal stability of furfural permits long continuous operation between turnarounds.

Begin your investigation of the use of furfural to enrich your naphthalene feed stock by writing for Bulletin 203-A, "Physical Data On QO Furfural."

The Quaker Oats Company

CHEMICALS DIVISION

The Quaker Oats Company — CHEMICALS DIVISION — QO CHEMICALS

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Swift & Company, Ltd., Sydney

In Japan:
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PLUS INGREDIENTS in KOPPERS Gran-U-Flow™ Petroleum Dyes

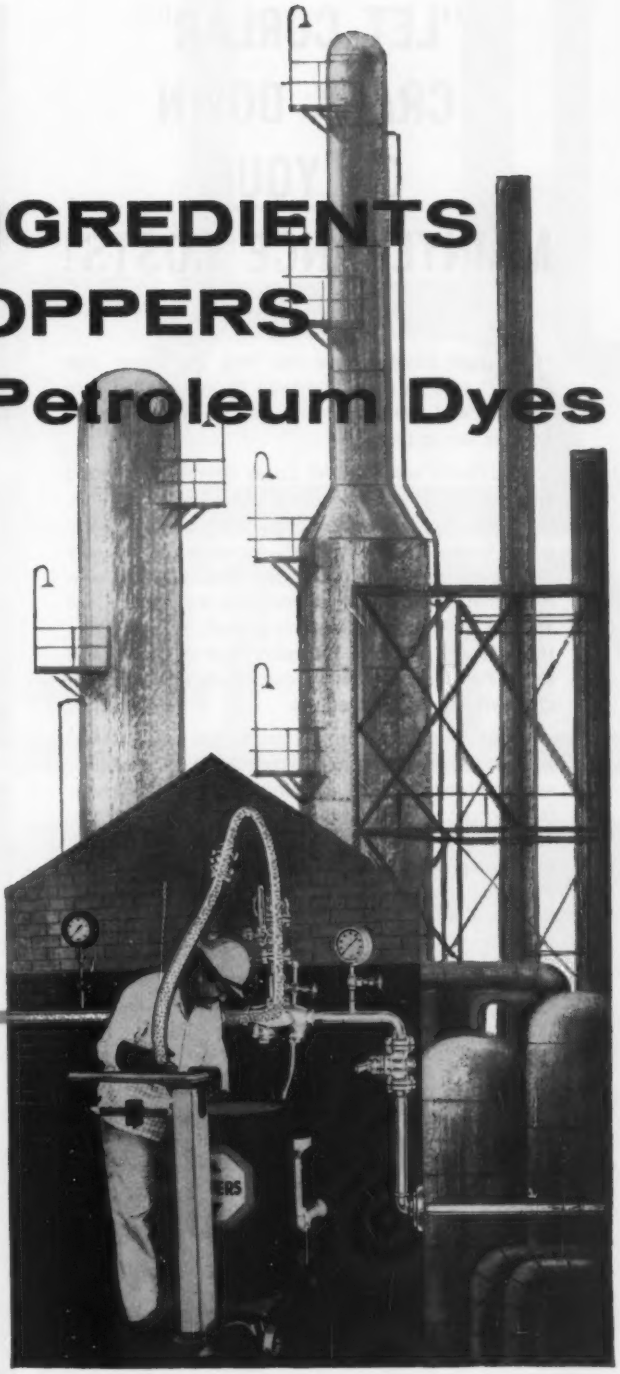
There *are* PLUS INGREDIENTS . . . in Koppers Gran-U-Flow Dyes . . . extra reasons why you should specify Koppers:

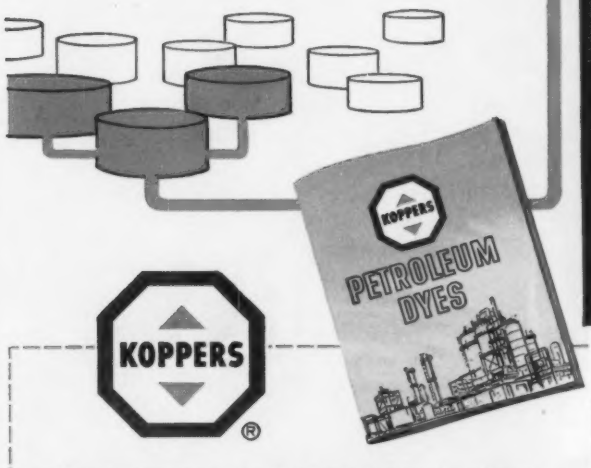
- unvarying uniformity . . . batch-to-batch
- high tinctorial strength
- dustless
- low benzene insolubles
- high solubility
- granular (Gran-U-Flow) . . . for *easy* flow

Whether you use petroleum dyes for gasoline, anti-freeze or a wide range of lubricants . . . for corporate identity, improvement of product appearance or ease of identification . . . you owe it to yourself to investigate the superior advantages of Koppers Gran-U-Flow Dyes.

Dye drums are color coded and designed for eductor systems in refineries.

Clip the coupon below to your company letterhead for a booklet showing newest eductor techniques. A free laboratory kit is also available. VMA 6982





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☐ Please send booklet on newest eductor techniques.

☐ Please send free laboratory kit for Gran-U-Flow Petroleum Dyes.

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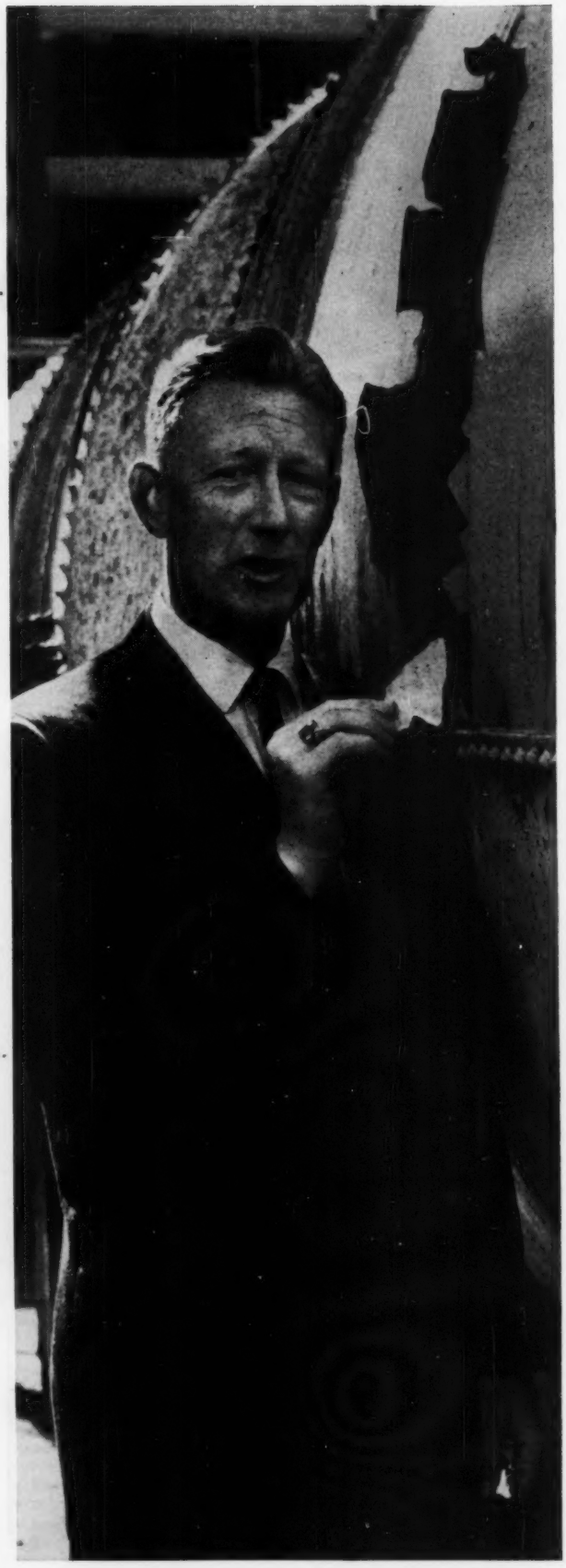
CLIP TO YOUR COMPANY LETTERHEAD.
Mail to our Pittsburgh office or nearest branch.

"LET CORLAR(TM) CRACK DOWN ON YOUR MAINTENANCE COSTS!"



"Premature paint failure like this plays hob with profits," says Du Pont Technical Representative Pete Sikkel. "And more often than not, so-called 'bargain' finishes are to blame.

"Du Pont's new CORLAR Epoxy Chemical-Resistant Enamels, on the other hand, solve this kind of problem. CORLAR grew out of continuing research to develop a new kind of protective finish—for really difficult conditions caused by highly corrosive atmospheres involving mineral acids, alkalies, moisture and heat. Once applied, CORLAR enamels form a tough, molecular film that literally locks out corrosion. And of course, like all Du Pont finishes, they're chemically engineered to cope with specific situations.

"Just as important as the paints you use, however, is the way you use them. Which is where Du Pont's system of maintenance painting brings you an important bonus: expert technical assistance, to help you effect the kind of savings that turn maintenance dollars into profit dollars. Our recommendations, based on a careful analysis of your problem, assure effective, long-term protection at lowest cost per square foot per year!"

Over 11 years' experience with corrosion problems makes Pete Sikkel typical of the able, expert help you can expect from Du Pont. Why not call your local Du Pont district sales office the next time you have a corrosion problem? For facts on the finishes mentioned here, just clip and mail the coupon below.

E. I. du Pont de Nemours & Co. (Inc.)
Finishes Division, Department PR-19
Wilmington 98, Delaware

☐ Please send me, without obligation, technical bulletin on CORLAR.

☐ Please have Du Pont Technical Representative schedule a call.

Name_____

Firm_____

Address_____

City_____ Zone____ State_____

MAINTENANCE PAINTS

DU PONT

REG. U.S. PAT. OFF.

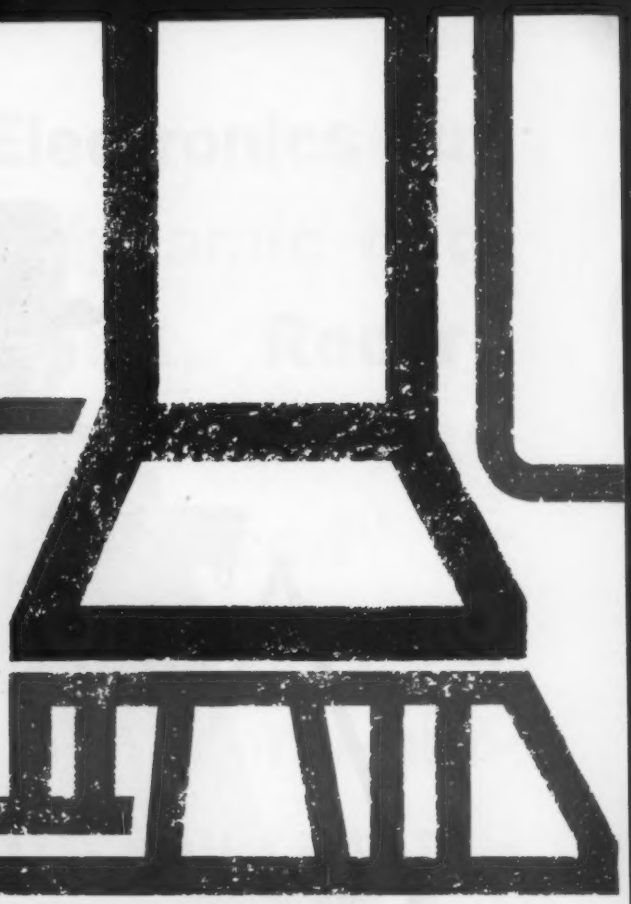
BETTER THINGS FOR BETTER LIVING...*THROUGH CHEMISTRY*

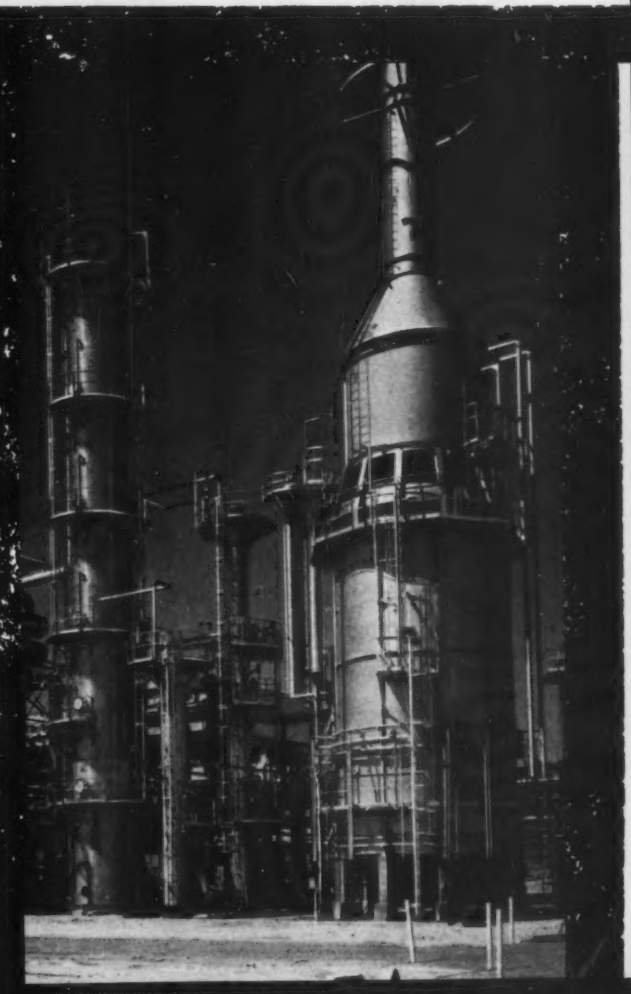
Procon completes African refinery 4 months ahead of schedule

Sixteen months to build a refinery in Mozambique . . . on the east coast of Africa near the port of Lourenco Marques . . . at considerable distances from the industries where almost all the refinery equipment had been constructed.

But build it Procon did! Not in 16 months—but in 12 months. Four months ahead of schedule! A modern 12,000 BSD refinery, it includes Platforming®, Unifining®, Merox™, and crude distillation units plus complete supporting facilities.

On stream for Sociedade Nacional de Refinacao de Petroleos (SONAREP) a subsidiary of the Portuguese petroleum marketing firm, Sociedade Nacional de Petroleos (SONAP), this refinery is another tribute to Procon's proven capabilities... to tackle the toughest job ...and complete it in the shortest possible time.





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DES PLAINES, ILLINOIS, U.S.A.
World-Wide Construction for the Petroleum, Petrochemical and Chemical Industries.

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I'll be back Thursday—

CATALYTIC ENGINEERS get out of the office into the field for frequent progress checks on jobs under construction . . . Catalytic engineers advise construction crews and supervisors . . . Catalytic engineers follow through.

This cooperation between home office and project location is another extra that makes it profitable for you to deal with us.

CATALYTIC
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PHILADELPHIA 2, PENNSYLVANIA • In Canada: Catalytic Construction of Canada, Limited; Sarnia, Ontario

Now from **Dresser Electronics** buy **or lease** a portable dynamic data processing trailer unit. **Record data** on-site, on-line, with your process operating "induced" or normally. Data on tape ready for **direct entry** into your general-purpose **computer.** Analysis lets management **decide process changes** to make for **better plant profit.** **Don't wonder any more** whether you should use computer control, make process changes, or replace older equipment. Now find the important variables and **what to do about them!**

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WALWORTH

TAKES THE WRAPS
OFF ANOTHER
FIRST IN VALVE
ENGINEERING

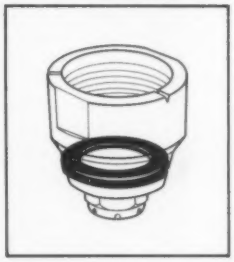
NEW BUBBLE-TIGHT BRONZE GLOBE VALVE

with

DUAL SEALING

ABSOLUTELY BUBBLE-TIGHT!

Here's the newest concept in valve design. Resilient unplasticized resin insert gives absolute shut-off in critical piping—at low torque. Now available for your particular requirements, the new Walworth Bubble-Tight Bronze Globe Valve is already in service aboard nuclear submarines, and in cryogenic gas piping systems—and is particularly suitable for the most critical water, oil and gas piping systems.



DUAL SEALING This unique unplasticized resin insert provides full 360° seal against matching monel seat. Secondary metal-to-metal seating further assures tightness... consistently. Write for descriptive bulletin.

WALWORTH

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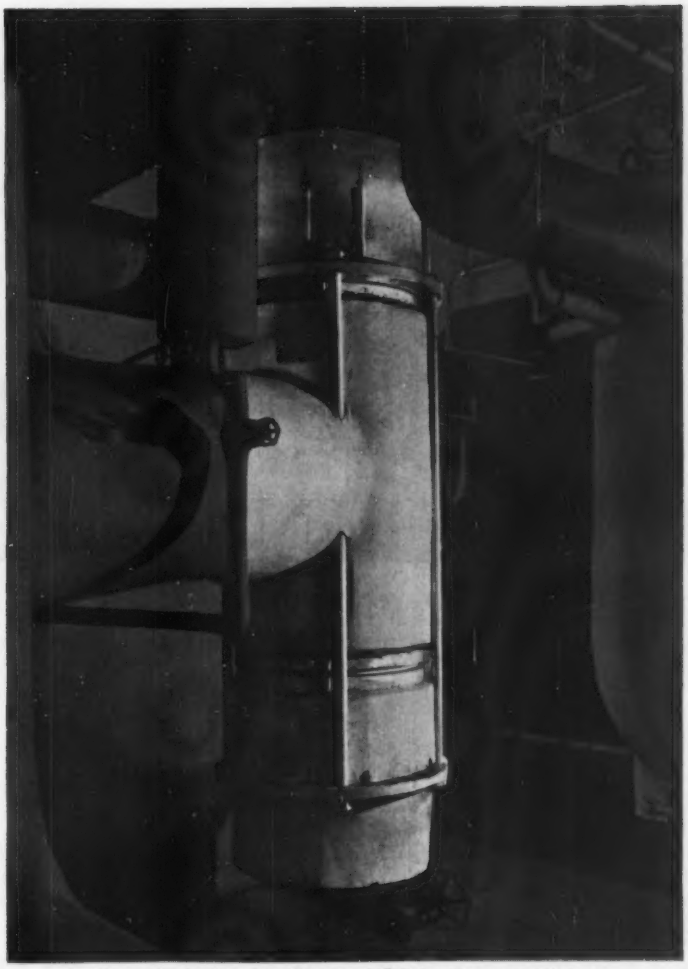
The Walworth Companies: Alloy Steel Products Company ■ Conoflow Corporation ■ Grove Valve and Regulator Company ■ M&H Valve and Fittings Company ■ Southwest Fabricating & Welding Co., Inc.

"Businessmen are too often antagonistic to government. And some in government have found it politically useful to harass business. We could do with a lot more understanding and a lot more realism on both sides." *–M. J. Rathbone, President*

Standard Oil Company (New Jersey)

(WHOSE PRINCIPAL U. S. OPERATING AFFILIATE IS HUMBLE OIL & REFINING COMPANY)

In the foreground, a 20" ZALLEA Universal Expansion Joint absorbing lateral movement.



At a major Eastern oil refinery, a 20" Zallea Pressure Balanced Expansion Joint installed on a steam turbine exhaust nozzle.

it's ZALLEA for maximum reliability... the tough jobs show why

Six tough Zallea Expansion Joints protect three 10,000 kw turbine generators from the wallop of thermal stresses . . . real hot-spot duty. Each generating unit has a 20" pressure balanced, self equalizing expansion joint installed at the turbine exhaust nozzle to absorb reaction load due to internal pressure acting against the turbine casing. A 20" universal expansion joint absorbs lateral deflection in the pipe run from the pressure balanced unit. Temperatures range from 0° to 615° at start-up, back to 475° in operation, at 200 psig. To cope with these cycles, the turbines demand—and get—the maximum reliability of Zallea Expansion Joints.

Whatever the service, none of the many factors affecting Zallea Expansion Joint reliability are left to guesswork. Zallea Expansion Joints are hydraulically formed. Advanced welding techniques insure welds having the same thickness, strength and physical properties as the parent metal. Zallea has done more cyclic testing to destruction than all government agencies and industrial firms combined. Zallea has produced more expansion joints than any other manufacturer . . . offers you more application engineering experience. These are just a few of the reasons Zallea Expansion Joints can and do outlive the equipment they serve. Sooner or later, ordinary expansion joints hand you a bill for unscheduled downtime, lost output.

Got a tough one coming up? Call in an experienced Zallea design and application specialist. Knows every inch of his product, can assist with every facet of your problem. And write for catalog 56, Zallea Brothers, Taylor and Locust Streets, Wilmington 99, Delaware.

Zallea

for maximum reliability

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS

REPORT TO REFINERS:

HOW MUCH CAN CHEMICAL ADDITIVES DO FOR REFINED PRODUCTS?

ARMOUR IDEA CHEMICALS

an informative look at the use of Armour Idea Chemicals in gasoline, fuel oil, lubricants, asphalts... plus a glimpse at the research that is helping to solve today's problems and investigating tomorrow's needs

GASOLINE ADDITIVES

More and more petroleum refiners are becoming aware of the abilities of Armour Duomeen® and Armeen® compounds as gasoline additives.

Duomeens O and C adsorb onto the metal surfaces of carburetors, forming monomolecular films which function as effective anti-icers. As a result, moisture—which causes engines to stall at temperatures around 36° F.—does not adhere to the surface. Even though ice particles may form under extreme conditions, they will not collect on the carburetor surface to block the flow of the air-gas mixture.

Recent investigations have revealed another important ability of Armeens and Duomeens: they help maintain engine cleanliness when used in summer gasolines.

Armour researchers are continually investigating the other Idea Chemicals for use as gasoline additives. Recent tests demonstrate that a new class of polyfunctional amines offer outstanding performance as corrosion inhibitors, de-icers and detergents.

FUEL OIL ADDITIVES

To supply bright, sludge-free fuel oil is the ultimate aim of every refiner. Many factors have made this a difficult goal to reach: stocks, fuel blends, transportation difficulties, processing. These conditions often result in fuel oil instability, which is further aggravated by the long storage periods necessary between peak seasonal demands.

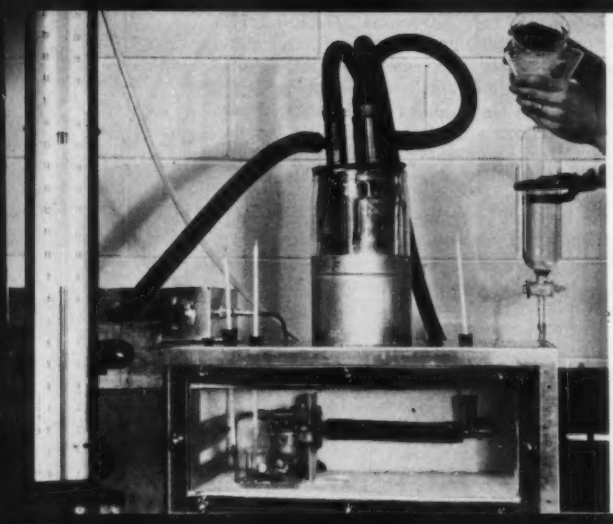
Two Armour chemicals relieve the problem. Armour Armolad® compounds help inhibit sludge formation; Armour Arquad® additives disperse it when it is already present.

The Armolads disrupt the normal chain reaction of oxidation and polymerization—thus minimize gum formation. In addition to stabilizing the oil in this manner, they also maintain color and filterability.

Armour Arquads 2C and 2S provide the ounce of prevention that's worth a pound of cure. These cationic surface active agents peptize the sludge while it is in the tank; the sludge thus passes through the burner system without plugging filters and nozzles. Arquads also act as detergents. Sludge already deposited on the screen can be resuspended and dispersed as described above. Another common source of possible contamination—mixing of fuels by the consumer—can be remedied also by the presence of a good dispersant additive.

LUBRICANT ADDITIVES

With advances in technology, lube oil requirements have become increasingly demanding. A progressive research program has been established at Armour to improve lubricant performance characteristics, such as wettability and lubricity.



ARMOUR RESEARCHERS AT WORK

TESTING CARBURETOR DE-ICING... At left is a test determining the ability of Armour additives to prevent carburetor icing. The carburetor is enclosed and air and humidity are uniformly maintained. A vacuum pump operates the carburetor, and icing is determined by the increase in vacuum. Armour chemicals are then tested for speed and efficiency of de-icing.

TESTING OIL STABILITY... Here, at right, an Armour technician measures the oxidation stability of turbine and hydraulic oils. The oils are placed in a controlled-temperature bath. Oxygen is bubbled through at a determined rate and the solution is then tested for acid and gum formation, viscosity stability, and corrosion.

Careful scrutiny is being given to the area of synthetic lubricants. Recent tests reveal the efficiency of tertiary amine chemicals in stabilizing synthetic diester lubricants. One of these tertiaries, Armeen M2HT, reduces the acid attack on bearings at concentrations as low as 0.1%.

ASPHALT ADDITIVES

In recent years greater use is being made of asphalt emulsions because they are less expensive and less hazardous than asphalt cements. Also, they can be stored and applied at much lower temperatures.

Armour cationic chemicals serve as efficient emulsifiers for new cationic asphalt emulsions. Duomeen T, because of its superior adhesion characteristics, develops a firm bond between the asphalt and aggregate; displaces water; prevents stripping. Atmospheric conditions have little effect on the adherent properties of the emulsified asphalt: deposition is rapid on either wet or dry surfaces.

In addition to cationic asphalt emulsifiers, Armour also produces Redicote® anti-stripping agents for asphalt cutbacks. The addition of as little as 0.2% Redicote to the asphalt will improve adhesion of asphalt to a wet or dry aggregate surface.

CHEMICALS THAT HELP INHIBIT ACID AND CORROSION

Refiners have found Armour chemicals useful in the field of metal cleaning. Small amounts of Armohib® additives retard acid attack on metals without diminishing the cleaning action of the acids. Armohibs are easy to use; liquid; readily soluble in acids; nonstaining; do not precipitate while standing. They offer users low-cost, dependable acid inhibition over a wide range of temperatures.

In addition, Duomeens and Duomeen salts are effective as refinery corrosion inhibitors. In treating pipe still overheads and light hydrocarbon streams, these chemicals perform efficiently at temperatures of 250-500° F., and concentrations of 6-12 ppm.

REORGANIZATION

The Armour Industrial Chemical Company has reorganized its derivatives department in order to offer you quicker, more expert technical assistance. Your Armour representative is now a member of our newly formed petroleum section—a department composed entirely of petroleum experts...men who know the oil business and understand its problems.

The new home base of this department is in Dallas, Texas, focal point of activity in the oil industry.

Call your petroleum chemical expert today. Let him show you how you can put Armour Idea Chemicals to work—productively...economically. For complete details on Armour Idea Chemicals for oil refining, send the coupon.

Petroleum Chemical Sales Department

Armour Industrial Chemical Company

One of the Armour Chemical Industries

5738 N. Central Expressway/Dallas 6, Texas

ARMOUR INDUSTRIAL CHEMICAL COMPANY
5738 N. Central Expressway, Dallas 6, Texas

Please send me your booklet on
Armour Idea Chemicals for Oil Refining.

Name..... Title.....

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City..... Zone..... State.....

For more data on advertised products, use cards, last page.

GAR-LINE PENTON TANK LININGS

for High-Temperature Corrosion Proofing

Can be applied to virtually any surface or contour to give superior, low cost protection against high-temperature corrosion. GAR-LINE Penton Tank Linings are replacing and outperforming more expensive materials in an ever-increasing number of applications.

Serviceable at temperatures up to 280°F, these efficient linings embody outstanding tensile strength, excellent dimensional stability and low water absorption. Chemically, they resist bleaching agents, solvents, plating solutions . . . in fact, all inorganic acids except fuming nitric and fuming sulfuric.

Applied by carefully selected and authorized applicators. The experience of these tank lining experts guarantees satisfactory GAR-LINE Penton installation, prevents expensive failure due to improper application. Approved applicators include:

ABRASION & CORROSION ENGRS.
1205 N. McMasters Street
Amarillo, Texas

ATTBAR PLASTICS
1107 Northeast 106th Street
Vancouver, Washington

BARTHEL CHEMICAL CONST. CO., INC.
P. O. Box 1025, Tacoma 1, Wash.

BITTNER INDUSTRIES, INC.
91 Diaz St., P. O. Box 10265
Prichard, Alabama

BUCKLEY IRON WORKS
21 Christopher St., Dorchester, Mass.

BUFFALO LINING & FABRICATING CORP.
73 Gillette Ave., Buffalo 14, N.Y.

CEILCOTE COMPANY, INC.
4832 Ridge Rd., Cleveland 9, Ohio

CHEMICAL PROOF OF SEATTLE
625 Alaska Ave., Seattle, Wash.

ELCHEM ENGRG. & MFG. LTD.
P. O. Box 249
Burlington, Ontario, Canada

ELECTRO CHEMICAL ENGRG. & MFG. CO.
750 Broad St., Emmaus, Penn.

THE FABRI-FORM COMPANY
P. O. Box 125, Byesville, Ohio

FLORIDA CORROSION CONTROL
P. O. Box 10082, Jacksonville 7, Fla.

THE FORTUNE COMPANY
1100 W. 37th St.—North
Wichita 14, Kansas

GALIGHER COMPANY
545 West 8th—S., Salt Lake City, Utah

GATES RUBBER COMPANY
Denver, Colorado

GOLDEN PLASTICS CORP.
333 East 8th St., Oakland 6, Calif.

GOODALL RUBBER COMPANY
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Melrose Park, Illinois

HANSZEN PLASTICS COMPANY
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Dallas, Texas

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Little Ferry, New Jersey

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ST. LOUIS METALLIZING CO.
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Watertown, New York

WILLOW RUN RUBBER COMPANY
12575 Haggerty St., Bellville, Mich.

Tailored to your specific needs, GAR-LINE* Penton** Linings can be applied to a variety of complex shapes as shown in these photos.

Investigate GAR-LINE Penton Tank Linings as the answer to your corrosion problems. For more information, contact the applicator nearest to you. Or, write for data on Penton; information also available on Teflon† linings for Anti-Stick or corrosive applications. Special Products Dept., Garlock Inc., P. O. Box 612, Camden 1, New Jersey.

*Garlock Registered Trademark
**Registered Trademark, Hercules Powder Company
†Registered Trademark, The DuPont Company

GARLOCK

Here's Why Oil Men Specify
EC&M HIGH VOLTAGE STARTERS

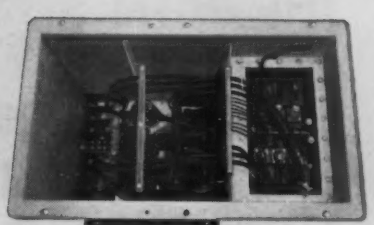
EC&M Type ZHS Starters at Southwestern pipe line trunk station

Designed for Easier Installation, Inspection and Maintenance

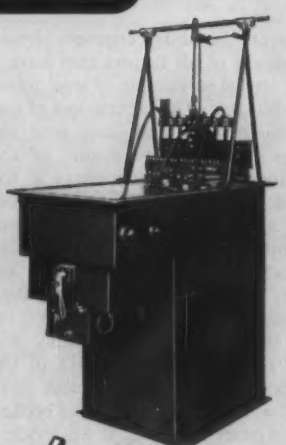
Specifically designed for Class I, Group D, Division 2, semi-hazardous locations . . . NEMA 3R (raintight enclosure). 50,000 KVA interrupting capacity.

***Fast* installation** because starters are shipped with all internal wiring complete. All leads are of anti-syphon construction.

Easy inspection • Contactor and overload relay panel may be raised, as one unit, above oil level. No disconnecting of bolts or leads. *(See lifting mechanism at extreme right.)* Safer, too . . . note view windows on each side of load-break disconnect switch.



View from above shows complete internal wiring . . . anti-syphon leads. These "ready-to-use" starters are complete with control transformer for 220 volt push button operation.



EC&M Contactor lifter raises contactor and overload relay above oil level for easy inspection. No bolts or leads to disconnect.

For literature describing EC&M's complete starter line, write for Bulletin 8131-T

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For more data on advertised products, use cards, last page.

HELPFUL WATER CONDITIONING DATA FROM BETZ

PRETREATMENT FOR EFFECTIVE

■ Rapid film formation by pretreatment can vastly improve cooling water corrosion control. The benefits are many and the added costs are negligible.

THE ADVANCES MADE in the control of corrosion in open recirculating cooling water systems over the past decade have been phenomenal. The Dianodic methods[1] for corrosion control are capable of decreasing the corrosion rate of steel to 1 mil per year or less with the pitting function totally prevented or definitely stifled. Excellent protection is secured with treatment concentrations generally in the range of 30 to 100 ppm, depending on operating conditions and water characteristics. Because steel can be protected economically many of the newly designed plants include all-steel heat exchangers in place of the more costly and more commonly used Admiralty tubed heat exchangers. The cost of all-steel heat exchangers is approximately 60% of the cost of heat exchangers constructed with Admiralty tubes. Under these conditions the capital investment for a new plant is considerably less when steel is used.

However, the design engineer should be cognizant of all factors that have a bearing on the service life of steel tubed heat exchangers. The experiences of one plant designed with all-steel heat exchangers will illustrate several of the precautions that are necessary if the expected service life is to be secured. Shortly after this new plant went into operation, it was found that pressure drops across many of the heat exchangers were greater than anticipated. Examinations of the heat exchangers revealed that heavy tuberculation was present in the steel tubes and in the water boxes. Some of the tubes were blocked with tubercules that had broken free from other locations. It was evident that the handling of the bundles during construction of the plant permitted corrosion to start. The pressure of other work attendant with start-up did not allow sufficient time for initial cleaning of the heat exchangers for removal of debris, grease, and corrosion products that had accumulated during construction. No pretreatment of the heat exchangers was employed and the intermittent operation of the system permitted frequent periods of inadequate inhibitor concentrations so that corrosion progressed at a rapid rate.

A marked difference in the care of handling steel tubed heat exchangers compared to handling Admiralty tubed heat exchangers is evident from this and similar experiences. The corrosion rate of steel under these adverse conditions is many times greater than the corrosion of Admiralty and the quantity of corrosion products produced is proportionally greater. When steel tubed heat exchangers are employed, it is essential that care be exercised in the initial handling of the bundles to avoid corrosion during construction and initial start-up. It is mandatory to clean steel bundles and to pretreat them to render the metal surfaces passive.

Pretreatment

Most methods of corrosion control are based on forming a film that acts as a barrier to stifle corrosion. The rate at which the film or barrier forms will largely determine the effectiveness of the treatment. Materials that do not form films rapidly will permit corrosion to take place and the result will be incomplete film formation and continued corrosion. The rate at which the film forms is related to the inhibitor concentration.

The function of pretreatment is primarily to permit rapid film formation to stifle the corrosion reaction immediately by formation of a uniform impervious film. Under these conditions the low treatment levels will maintain the film intact and avoid the accumulation of corrosion products.

Reference to Figure 1, Curve A, shows the high initial corrosion rate of steel when exposed to Philadelphia tap water, fortified with 500 ppm of chloride, and at a temperature of 120 F. The application of 30 ppm of Zinc-Dianodic markedly decreases the rate of corrosion (to less than 1.5 mils per year at the end of 3 days). However, if the steel is first pretreated for rapid film formation with a treatment concentration of 500 ppm of Zinc-Dianodic for only 4 hours and thereafter treated with 30 ppm of Zinc-Dianodic an even greater reduction in the initial corrosion rate as well as the over-all corrosion rate results, as shown by Curve C.

The data contained in Figure 2, demonstrate the superior qualities of the film formed by 500 ppm of Zinc-Dianodic compared to 5000 ppm of chromate. Pretreatment with 5000 ppm of chromate for 2 hours permitted a 50% reduction in weight loss and a corresponding reduction in the amount of corrosion products that accumulate.

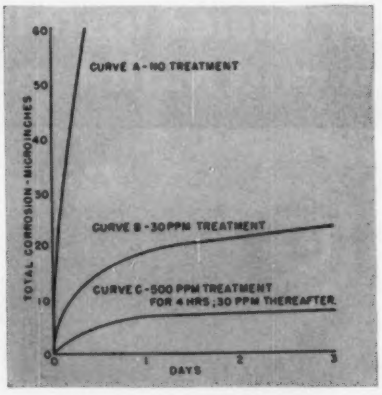

Figure 1

However, pretreatment with 500 ppm of Zinc-Dianodic for 2 hours permitted more than an 80% reduction in weight loss and a negligible accumulation of corrosion products.

The low treatment levels normally used for corrosion control in open recirculating systems should be viewed as the quantities required to maintain the film intact and to heal the slight breaks that may occur from minor variations in environment. Whenever any serious changes in environment occur that cause destruction of the film, corrosion products can accumulate before the film is re-established by the low treatment levels. Under these conditions, in order to secure maximum corrosion protection and to minimize accumulation of corrosion products, treatment levels should be increased to re-establish the protective film as rapidly as possible.

Pretreatment of steel heat exchangers is required . . .

. . . for all new bundles
. . . whenever the exchangers are acid cleaned
. . . whenever low pH is encountered
. . . whenever serious process leakage occurs
. . . immediately following start-up after inspections.

Care of Steel Exchangers

Initial Treatment

The care of new steel heat exchangers should start with the writing of the

[(1) Dianodic is a registered trademark. The methods are covered by U. S. Patents 2,711,391; 2,900,222; 2,872,281; 2,848,299.]

specifications. The design engineer should include as part of the specifications, a requirement that the units be delivered free of debris, grease and other foreign matter that may initiate corrosion, and that the units be protected from the weather during transit and prior to installation. As soon as possible after installation, and prior to placing the system in full operation, pretreatment should be applied to the circulating water to permit rapid film formation. A procedure of this type will avoid excessive pressure drops and assure maximum protection of the units as well as materially aid in achieving the anticipated service life of an all-steel system.

Other Factors

Once the film is properly formed, the normal treatment levels will serve to maintain the film and prevent corrosion under normal operating conditions. However, there are a number of factors that can destroy the film to such a degree that higher than normal treatment levels will be required to re-establish the film rapidly. For example, when an individual heat exchanger is acid cleaned, the film will be completely destroyed. Acid cleaning will leave the steel surfaces in a very active state and the initial corrosion rate will be very high. The normal treatment levels usually will not permit sufficiently rapid re-establishment of the film. Therefore, following acid cleaning and flushing, the unit should be pretreated.

The modern day corrosion inhibitors function best in a pH range of 6.0-7.0. This same pH range permits maximum protection to tower wood and is usually the pH range required to avoid calcium deposits. Therefore, acid treatment of the circulating water to control pH is a common practice. In the great majority of these systems excellent control of pH is maintained. On occasion, however, low pH values may develop. If low pH is permitted for any extended period of time, partial or complete destruction of the protective film may occur. When this occurs, treatment levels should be increased to re-establish the film as soon as possible.

In other systems, process leakage may introduce hydrogen sulfide and mercaptans. This type contamination will have an adverse effect on most films. Also, leakage of this type usually produces a drop in pH as well. Until such time that the leakage can be corrected the system should be blown down heavily. If it is established that a particular heat exchanger is a chronic offender, it should be equipped with blowdown facilities so that as much of the blowdown as possible is taken from the offending heat exchanger. Following correction of the leak, treatment levels should be increased to rapidly re-establish the film.

The periodic inspections required for most systems will produce conditions during start-up that may increase the initial corrosion rate. For example, brushing or manual cleaning of the water boxes or other parts of the heat exchanger may partially or totally remove the protective film. Debris and migratory corrosion products may settle at various points in the system. These and many other factors will create conditions conducive to corrosion. Pretreatment by the use of higher than normal treatment levels during start-up will assure rapid repair of the protective film and minimize the accumulation of corrosion products.

The precautions outlined above will be instrumental in achieving maximum service life from all-steel heat exchanger systems.

CORROSION CONTROL

Specimen	Pretreatment (2 hrs.)	Loss-mgs. (24 hrs.)
A	None	36
B	5000 ppm chromate	18
C	500 ppm Zn-Dianodic	6

Conditions—Philadelphia tap water fortified with 500 ppm chloride. Temperature 120 F. 24 hour exposure in 8 ppm of Zinc-Dianodic after pretreatment as indicated.

Figure 2

General Application

While much attention has been focused on the use of pretreatment for all-steel systems because of the higher corrosion rates that can occur, the principles of pretreatment have application to and will prove beneficial for cooling water systems in general. It is true that the initial corrosion rates for Admiralty tubes or tubes of copper alloys in general are materially lower than for steel, and therefore the effects of these less voluminous corrosion products are not as pronounced. However, where Admiralty tubed heat exchangers are employed the systems are bimetallic since the shells and water boxes are constructed of steel. While the Admiralty heat exchanger tubes are not adversely affected, the steel components of these units do undergo an initially high corrosion rate and produce voluminous corrosion products that interfere with proper and complete film formation. The application of the principles of pretreatment for rapid film formation, followed by the use of normal treatment levels for film maintenance will prove of benefit in minimizing corrosion of the steel parts of the system. In general, improved heat transfer, longer service life and less plant maintenance are the benefits that will be secured.

The Dianodic methods developed by Betz are the most effective corrosion control treatments for recirculating cooling water systems. Their effectiveness is due to the ability to form protective films rapidly and to maintain these films with relatively low treatment levels. The Betz Engineer in your area will be pleased to discuss corrosion control and the application of pretreatment to handle your cooling water problems. Why not contact him *today?*

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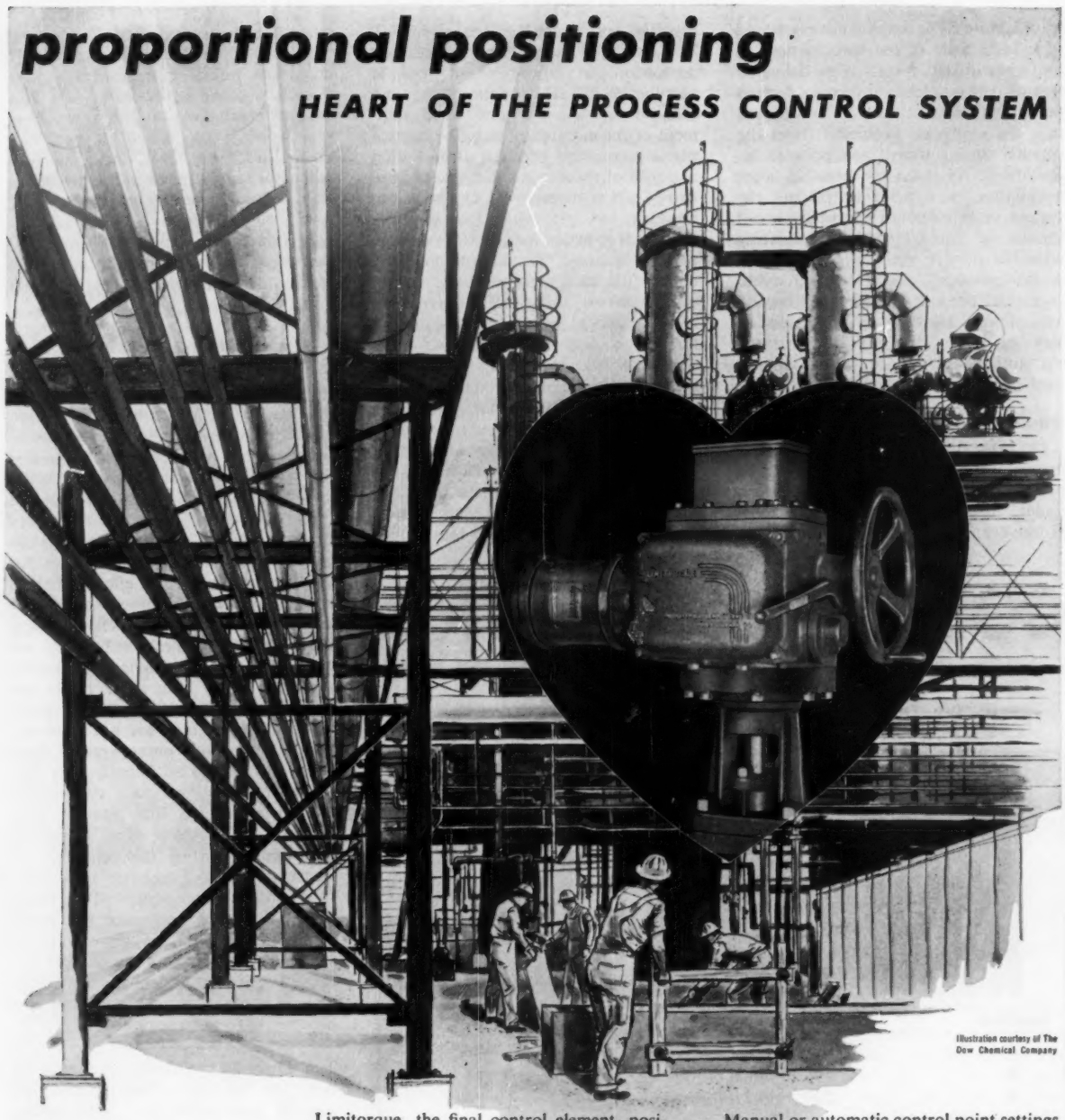

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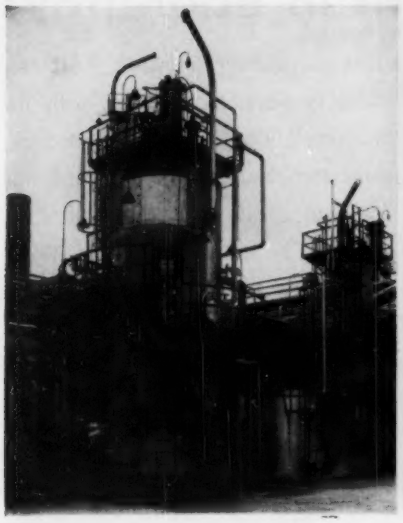

OHIO—Two of three two-stage ELECTROFINING Precipitators for treating kerosine, heavy cat gasoline, and light cat gasoline at Standard Oil Company of Ohio's Toledo refinery, which also utilizes a PETRECO Desalter.

CALIFORNIA—Richfield Oil Corporation, Long Beach, uses a PETRECO* Electric Desalter, a BENDER Catalytic Sweetening process, and four Petreco ELECTROFINING* Precipitators for gasoline, jet fuel, and kerosine treating.

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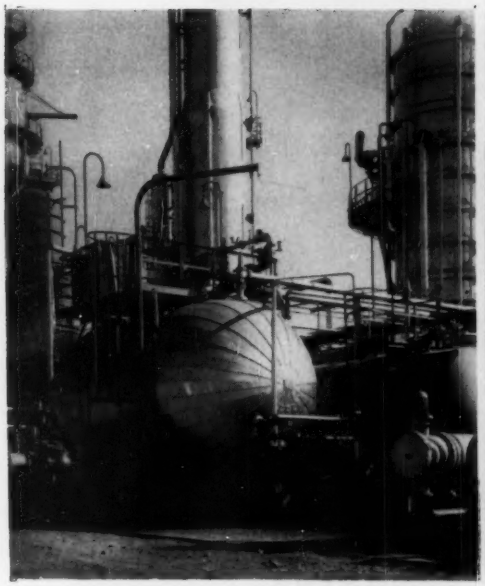
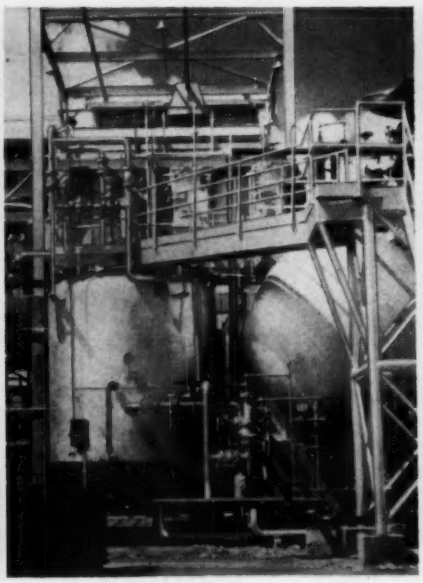
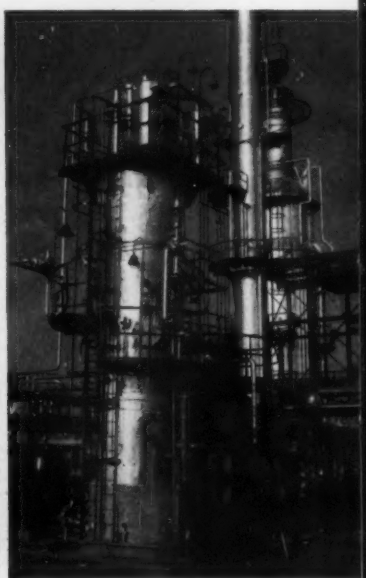


CHILE—PETRECO* Electric Desalter in ENAP Con Con refinery.

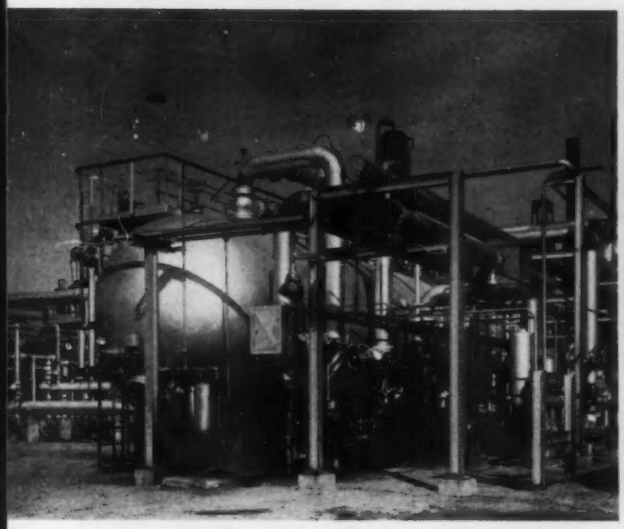


NETHERLANDS ANTILLES—Petreco ELECTROFINING Precipitator at a refinery in Aruba.



JAPAN—PETRECO Desalter and ELECTROFINING Precipitator installed in Kawasaki refinery of General Oil Company.

AR-61-1



TEXAS—Two-stage PETRECO Desalter in Sunray refinery at Shamrock, Texas.

DELAWARE—PETRECO Desalters on huge Tidewater Association crude unit at Delaware City refinery.

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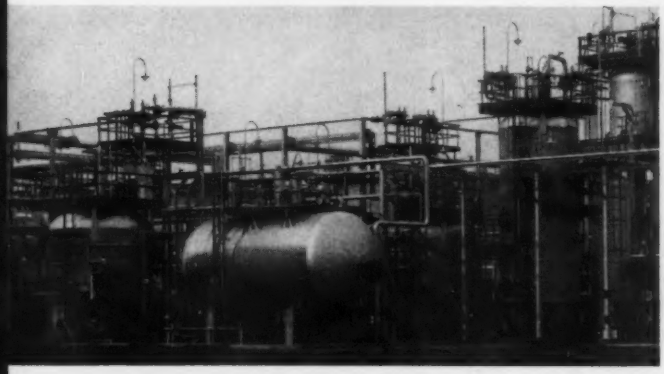
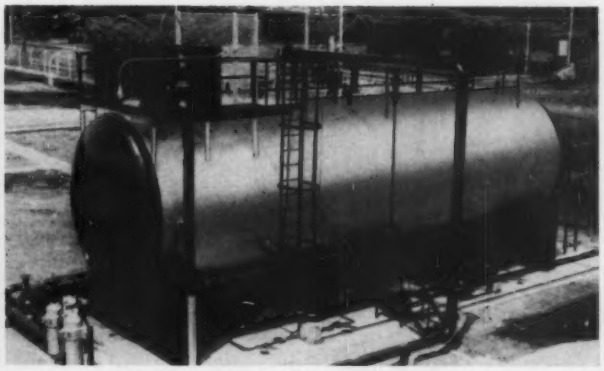


ENGLAND—Esso refinery at Milfordhaven includes PETRECO Desalter, and three Petreco ELECTROFINING Precipitators for distillate treating.



VENEZUELA—Shell Oil Company's PETRECO Desalter at the Tia Juana installation.

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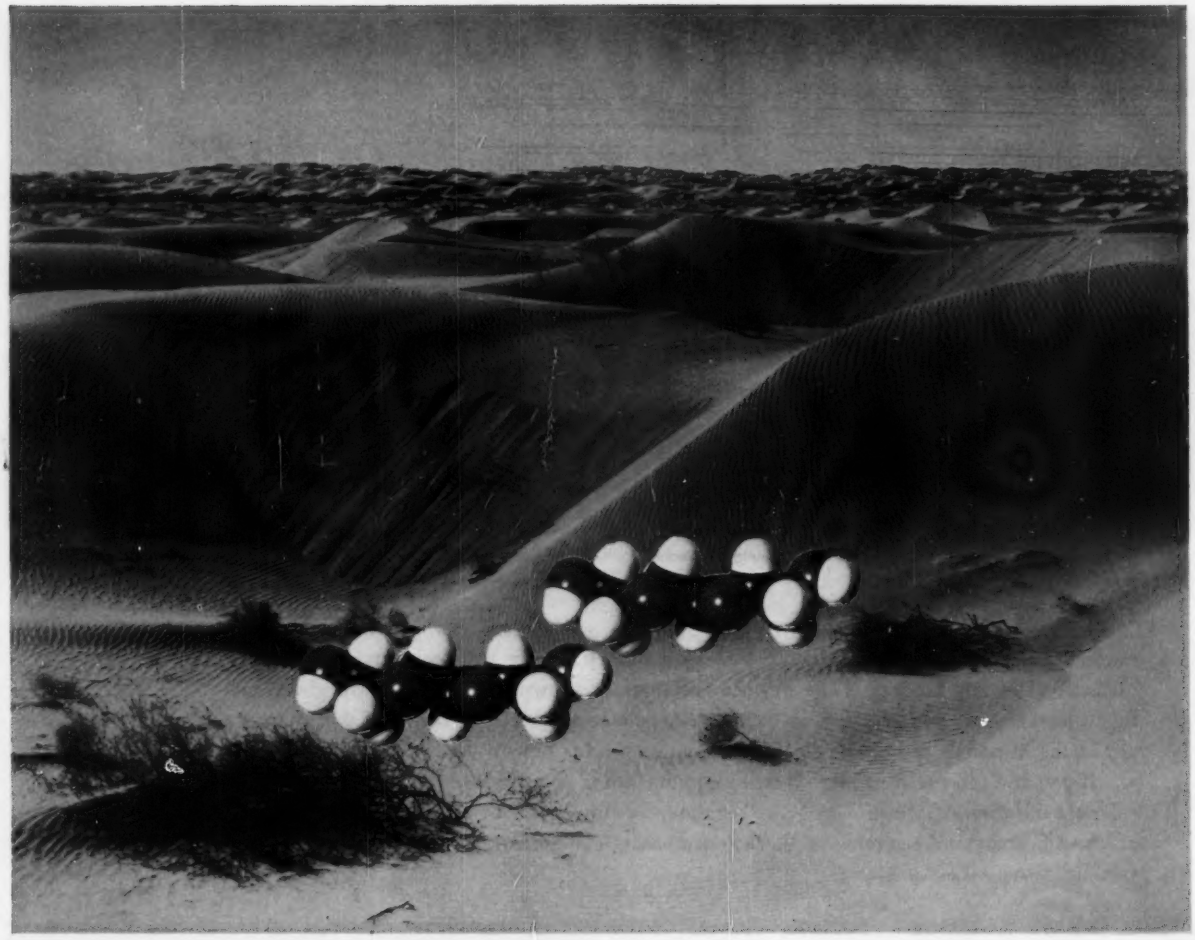

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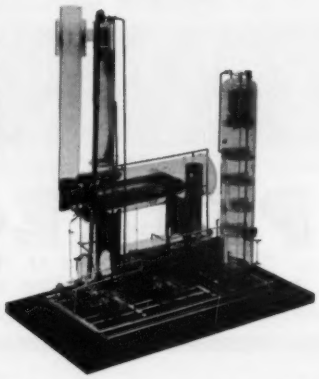

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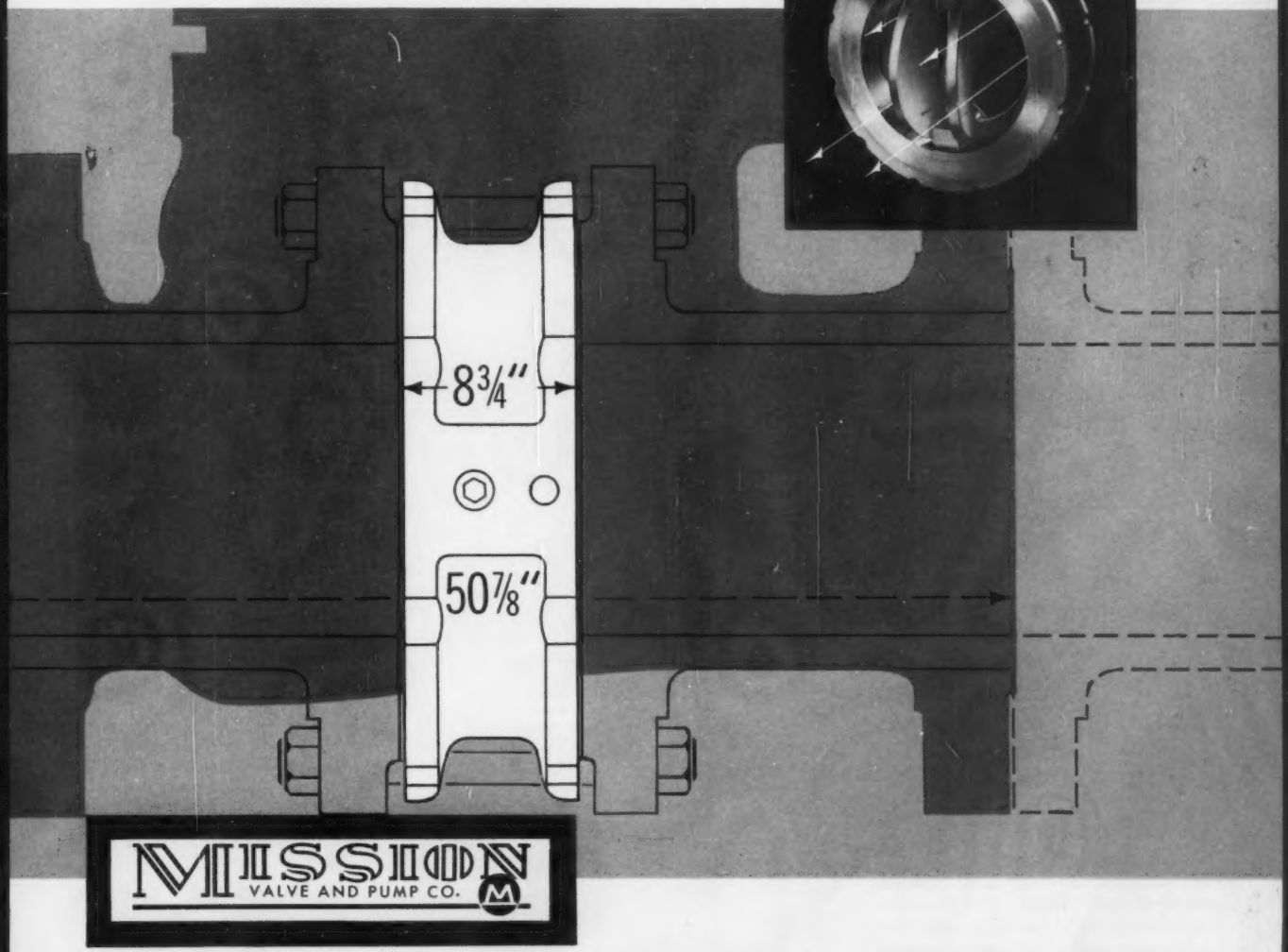

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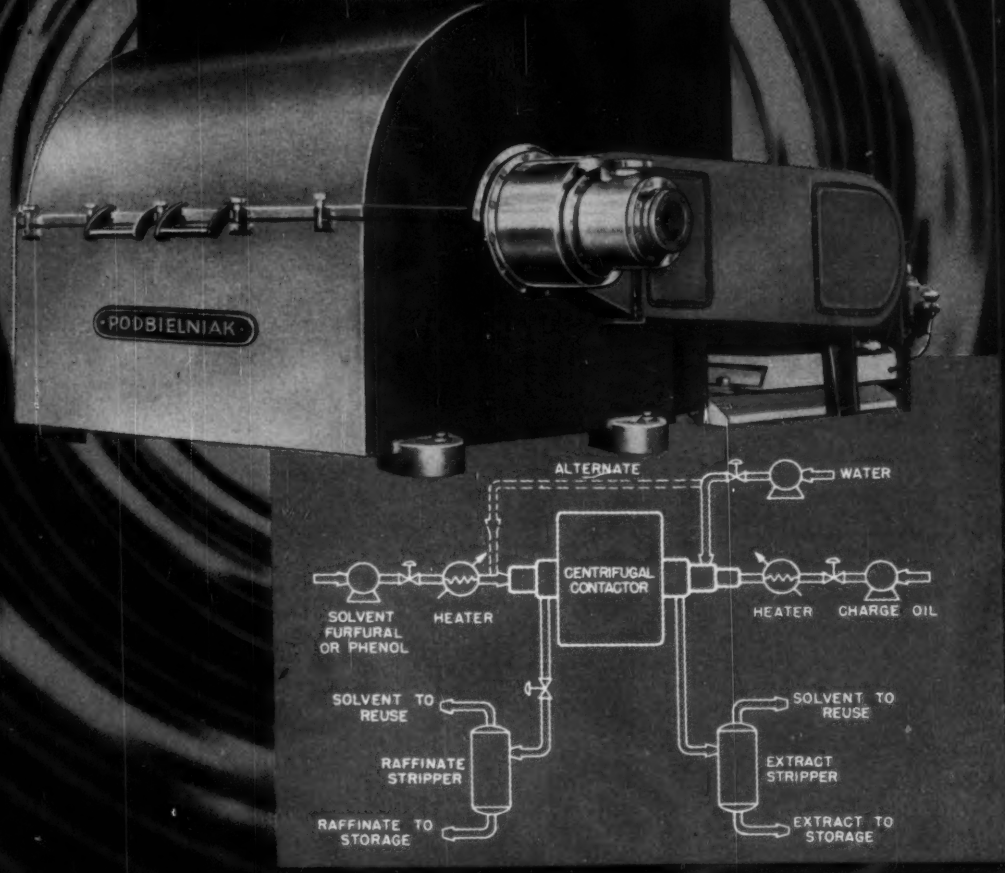

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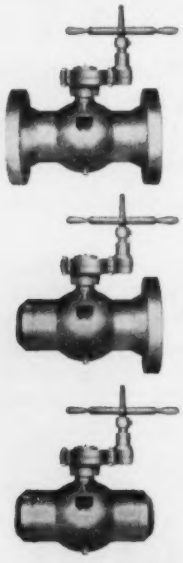

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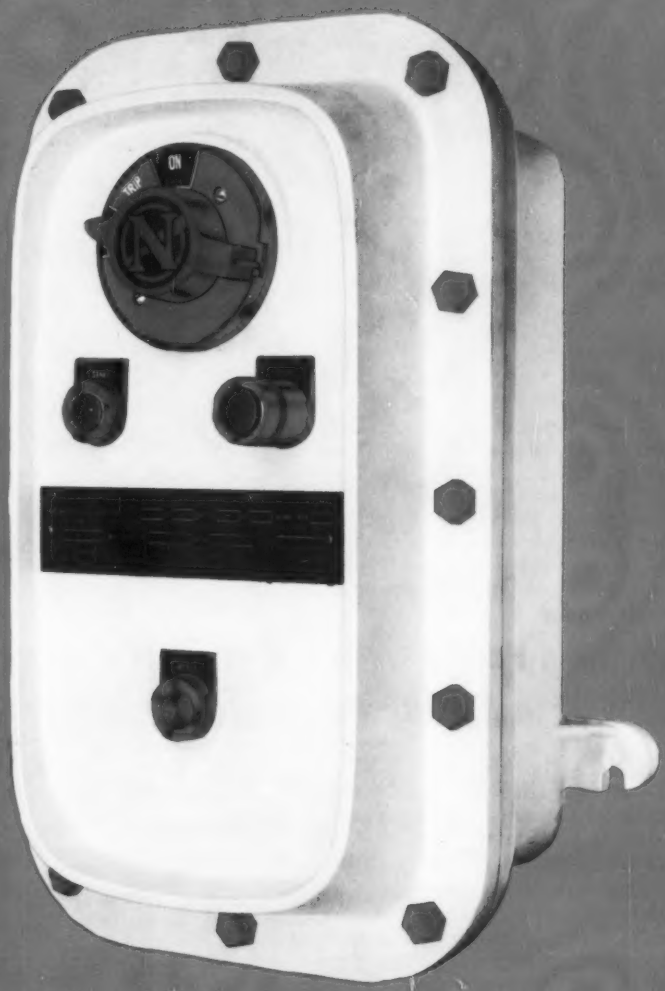

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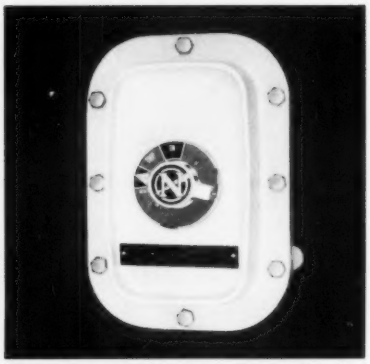
In making the announcement, H. A. Norberg, president of the firm, said "Although we have been an important producer and a leading supplier of electrical equipment for hazardous locations for over twenty years, we have not been satisfied with the approach to such equipment — neither ours nor our competitors.

H. A. Norberg

"To find the solution, we sent our marketing team to customers to discuss their problems. After this research was behind us, we engaged Mr. Wayne Porter — an outstanding industrial designer — who established the basic appearance of our new line.

"When we arrived at what was thought to be the final product, we built prototypes and took them to major users of this kind of equipment — over 100 design and maintenance engineers and purchasing people in the petroleum, petro-chemical, steel, milling and other industries. The men we talked with were most helpful. They spent hours with our marketing people, going over the new equipment. They told us what they liked, and what they disliked.

"After the survey, changes were made to incorporate most of the ideas brought out by interview. Now we have it. We call it the *White Line*. We feel sure it is the shape of things to come in electrical control equipment. And we invite you to become familiar with it at your earliest opportunity."



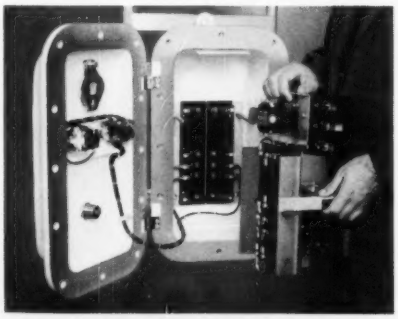
Nelson's new White Line Circuit Breaker includes enclosures for circuit breakers up to 1,000 ampere size. Notice the compact, rectangular design.

ELECTROL PLUG-IN COMBINATION STARTER IS STAR OF WHITE LINE

Prominent among the many advances found in Nelson's *White Line* is a new concept for hazardous area starters— the *Electrol*. These new starters were designed to satisfy modern requirements in today's automated refineries and chemical plants.

The new *Electrol* features complete plug-in components to make change-out a matter of minutes rather than hours. Critical processes are back on the line fast. Line, load and control wiring are all disconnected when the interior is removed. Both starter and circuit breaker, with optional extras such as control transformer, are pan mounted and are removed or inserted without the use of tools. The *Electrol* design — which requires from 23% to 50% less mounting space than competitive makes — includes starters through sizes 4.

For those who desire conventional mounting, non plug-in interiors are available at competitive prices. Sizes 5 and larger are available only in non plug-in design.



Plug-in feature of Electrol combination starter features line, load and control plug-in. Enclosures can be opened, plug-in components removed and replaced, enclosure closed and returned to service within three minutes.

NEW WHITE LINE BY NELSON FEATURES DESIGN CHANGES

One of the most striking changes is the white color of the enclosures. White is the best heat reflective color. This helps keep the interior cooler; in fact, 20° cooler by test — which results in less nuisance tripping and more accurate selection of overload heaters.

The white paint used has a specially selected vinyl base for maximum resistance to corrosion and abrasion. The use of white will eliminate the need of repainting enclosures after installation since the white blends with any color scheme.

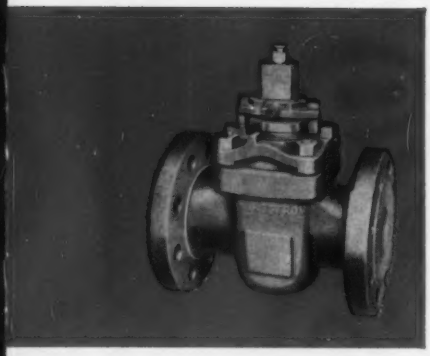
The shape of the new *White Line* enclosures is both functional and eye appealing. Fewer flange bolts are required because the enclosure is tailored to the equipment. The bolts are stainless steel, captive type which eliminates lost bolts and fumbling around. In addition, they are the quick-thread type — only one-and-one-half turns are necessary for removal. The raised ridge on the cover is more than decoration; it strengthens the cover and provides a protective recess for hand controls.

Covers on the new *White Line* are hinged to the box, except on the very smallest breakers. This makes servicing simpler and faster since the cover swings out of the way. There is nothing to interfere with complete access to the interior, no heavy pieces to lift and hold in place, and no way to drop the cover on the ground.

Designed to use every major brand of starter and circuit breaker, the *White Line* allows customers to keep spare parts inventory at a minimum, because they may specify the brand on which they have standardized.

Mounting of the new units is simple — due to a new 3-point mounting. This means the enclosure is always solid with no stress when mounted on uneven surfaces. The unit is easier to install, too. After installing the top mounting bolt, the enclosure may be hung on it leaving both hands free to put the remainder of the bolts in place. All *White Line* cast enclosures are available in either iron or aluminum.

In addition to the new starter and circuit breaker enclosures, the *White Line* also includes cast iron and aluminum junction boxes, lighting panels, control stations and power distribution panels.



seals tight: Let's get basic: The prime function of a valve is to shut off a line. And Rockwell-Nordstrom valves do this job better than any other valve on the market. They live longer, too, saving you money every year in valve replacement. The cost? No more than ordinary valves. Write for complete information.

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81 Rue de la Servette
Geneva, Switzerland

Please send me Bulletin V-217.

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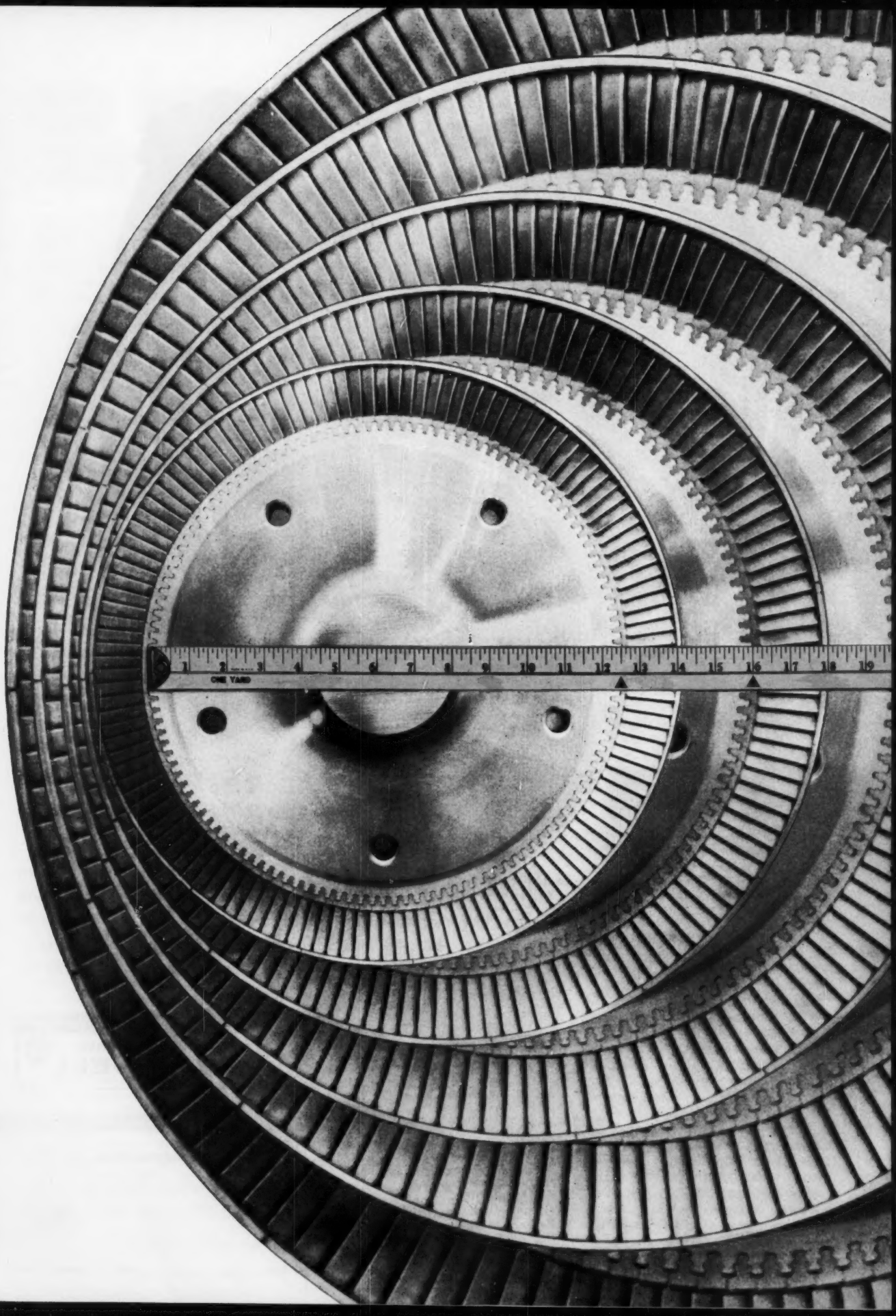
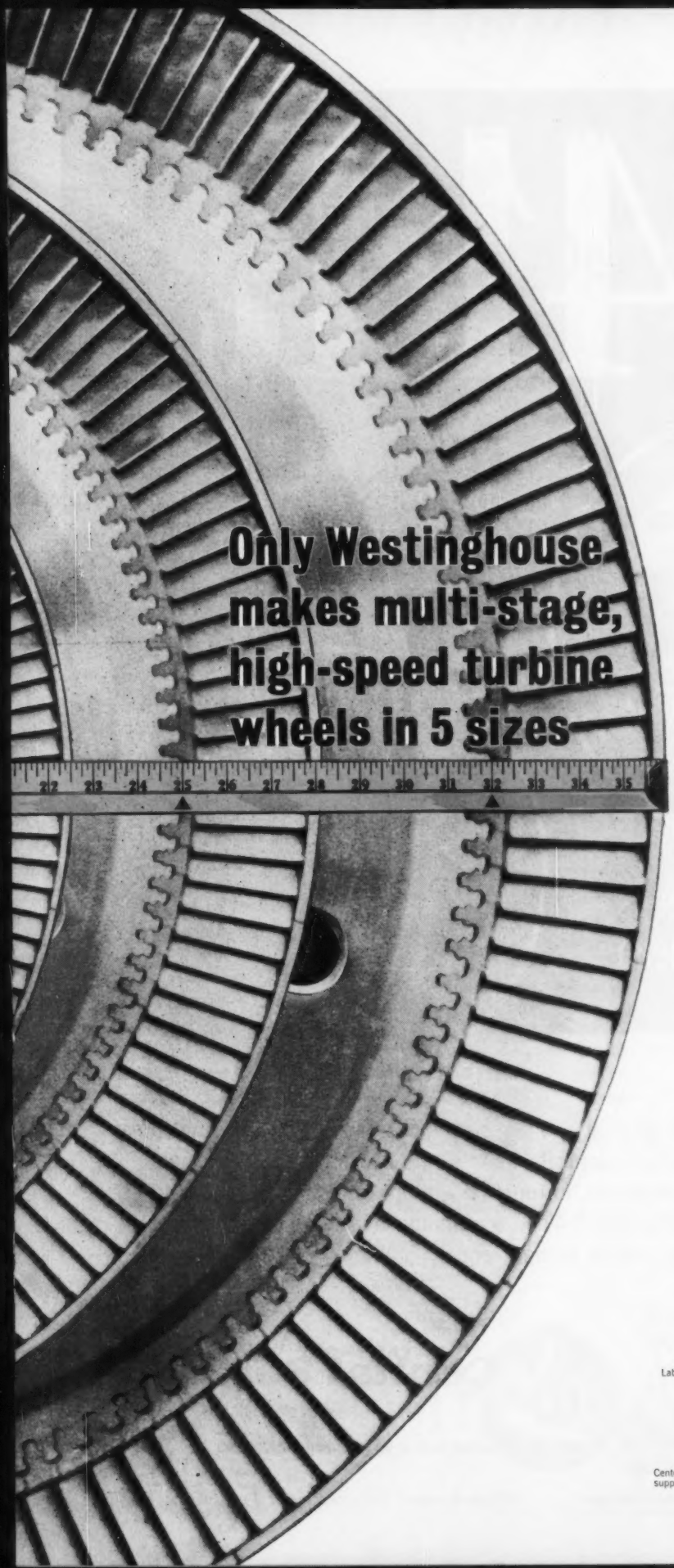
Company_____

Street_____

City_____ Zone____ State____


ONE YARD



FOR THE RIGHT SIZE TURBINE START WITH THE RIGHT SIZE WHEEL

Several things determine what size turbine will supply power within economic limitations . . . steam pressure and temperature, exhaust steam pressure, horsepower and speed requirements, cost of steam, and operating hours required for turbine pay-out.

To bring all these factors into as close a relationship as possible, Westinghouse high-speed M-line turbines are custom-engineered for each job. Yet they all follow one basic assembly method, using standardized components. Result . . . the reliable performance expected from a *standard* design, combined with the high efficiency expected from a *custom* design.

Determining the right wheel size is the first and key decision . . . and only Westinghouse makes high-speed turbine wheels in 5 sizes, 12½ through 32 inches. This wide range makes Westinghouse M-line turbines adaptable to any steam condition and speed up to 16,000 rpm, with capacities up to 32,000 hp and higher.

Wheels are installed on one of five different size turbine frames, selected to match wheel sizes. Then, according to job requirements, other standardized components are selected and added to the assembly.

Westinghouse M-line turbines have a number of exclusive features, such as modular type governors and serrated root blading. Check these five other features. You'll find them on all high-speed M-line turbines built by Westinghouse . . . world's most modern small turbine facility.

Oil relay governor, with package components. Specifically designed for high-speed service.

Multi-valve bar lift steam chest. Liberal volume. Special valve and seat design for maximum part load efficiency.

Centerline support of casing. Eliminates thermal misalignment.

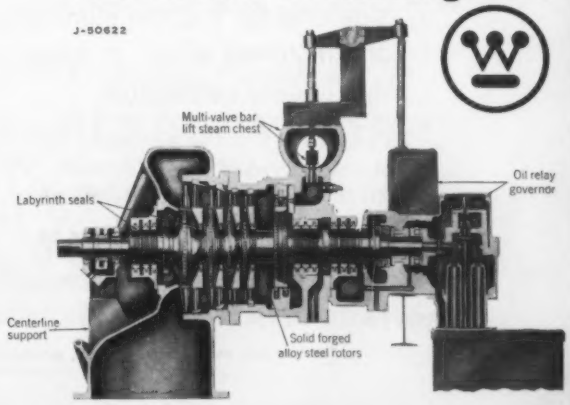
Solid forged alloy steel rotors for most applications. Critical speeds are well out of the operating range. Maximum operational dependability.

Labyrinth seals throughout. Eliminates maintenance and replacement required with rubbing type seals.

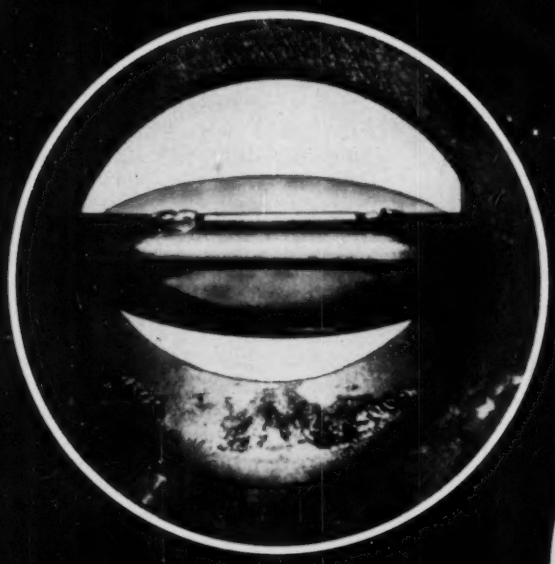
Send for new Descriptive Booklet B-8227 describing in detail the features of this new line of turbines. Write to Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

You can be sure . . . if it's **Westinghouse**

J-50622



S-41-K



. . . removes
carburetor deposits

keeps
carburetors clean . . .

At a minimum additive package cost S-41-K provides outstanding performance. It cleans-up carburetors in which deposits have formed and keeps them clean. S-41-K has been proven, in actual use, to function without introducing undesirable side effects. You can eliminate, with S-41-K, a common headache for mechanics and motorists alike . . . rough engine idling, frequent stalling and gasoline waste due to dirty carburetors.

For further detailed information write to . . .

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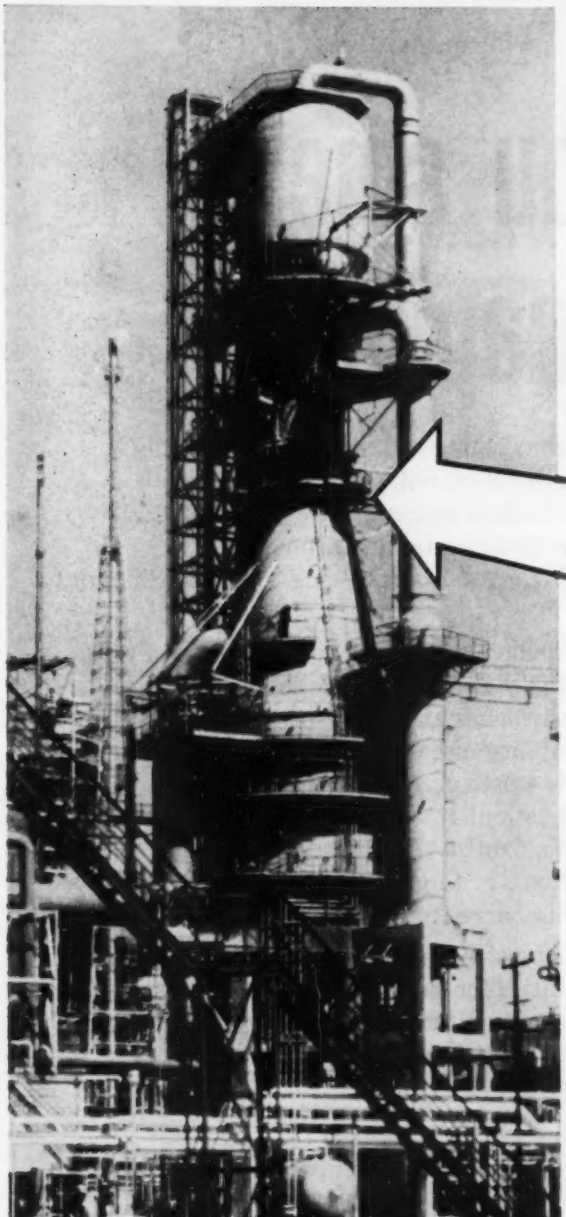
At *CRITICAL* Valve Control Points



WIDE RANGE OF SIZES:

Screwed end ¼" through 3".

Flanged 150# series ½" through 12" — 300# ½" through 8".

Larger sizes on request.

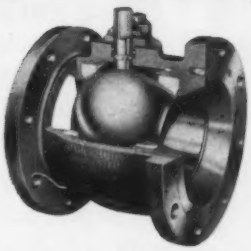
VARIETY OF MATERIALS:

Valves in 303 and 316 Stainless Steel, Alloy 20, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Interchangeable seats and seals in Teflon, Teflon compounds, Nylon, Buna-N, Neoprene, Hypalon and natural rubbers. Type DZ: Ductile Iron and Carbon Steel, Standard.
Other materials on request.

...You Get Dependable Operation with

jamesbury "Double-Seal"™ BALL VALVES*

*PATENTED.



FIRE SAFE VALVING IN REFINERIES

The Jamesbury "Double-Seal" FIRE SAFE Ball Valve (Type DZ) has been accepted for use in the hydrocarbon industry because of its outstanding performance. In the event of fire — and the loss of the valve's soft seats, secondary metal seats provide effective shut-off of the fluid flow.

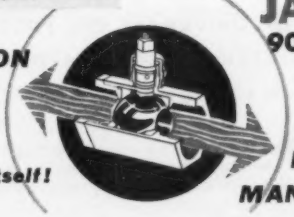
It stands to reason that a valve that performs outstandingly under adverse conditions can be relied on to give trouble-free performance under less severe conditions. That has been one of the big reasons, at least, for the success of Jamesbury "Double-Seal" Ball Valves. Proved dependable at *critical* valve control points, these valves have gone into industrial plants everywhere to control nearly all types of media flow.

There are many exclusive features about the Jamesbury "Double-Seal" Ball Valve which contribute to its excellent performance record. For example, there's Jamesbury's patented lip seal; there are no internal springs; you get leak-tight stem seals; operators are mounted integral with the valve. For further information about Jamesbury "Double-Seal" Ball Valves, contact your nearest stocking distributor — or write us direct.

Ask For Jamesbury Fluid Services Guide

JAMESBURY CORP.
90 New Street, Worcester, Mass.
DISTRIBUTORS IN PRINCIPAL CITIES

QUARTER TURN OPERATION
HIGH FLOW CAPACITY
ZERO LEAKAGE



NO LUBRICATION REQUIRED
MINIMUM MAINTENANCE
MANUAL OR POWER OPERATION

As Versatile As Industry Itself!

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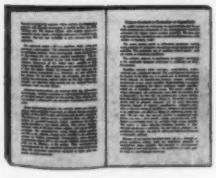
That odor you smell is money escaping!

The odorous fumes coming from your plant stacks are probably costing you much more than the good will of your employees and neighbors. For these odors often represent a wasted asset . . . a missed opportunity to lower your costs . . . through conversion of fumes to BTU's for use in processing, plant heating, or other operations.

Hundreds of installations in chemical plants . . . producing a wide variety of compounds including maleic and phthalic anhydride, synthetic fibers, resins, oils, varnishes and many others . . . have proven the economy and feasibility of converting objectionable organic and other combustible waste gases to money-saving fuels through Catalytic Combustion. In this proven process, all-metal catalysts and catalytic systems oxidize these gases by *low temperature, flameless combustion* . . . to give you usable energy and a low temperature, odorless discharge from your stacks.

High pressure processes, such as those for ethylene oxide and nitric acid, provide special opportunities for savings through tail gas power recovery. Incidental benefits often include reduced fire hazards, simplified cleaning maintenance, healthier working conditions . . . and better community relations.



For more details *on the economies possible write Dept. F for this brochure. Or, better yet, give us a few facts on your waste gas problem so we can make specific suggestions.*

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A SUBSIDIARY OF UNIVERSAL OIL PRODUCTS COMPANY

The world's first large commercial

ISOCRACKING* UNIT,

designed by
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for upgrading distillates
to premium high octane gasoline
will be constructed for
The Standard Oil Company (Ohio) in Toledo.

ENGINEERING, PROCUREMENT and CONSTRUCTION

of this new low temperature hydrocracking unit, rated at 7,500 BPD, is the responsibility of

PARSONS

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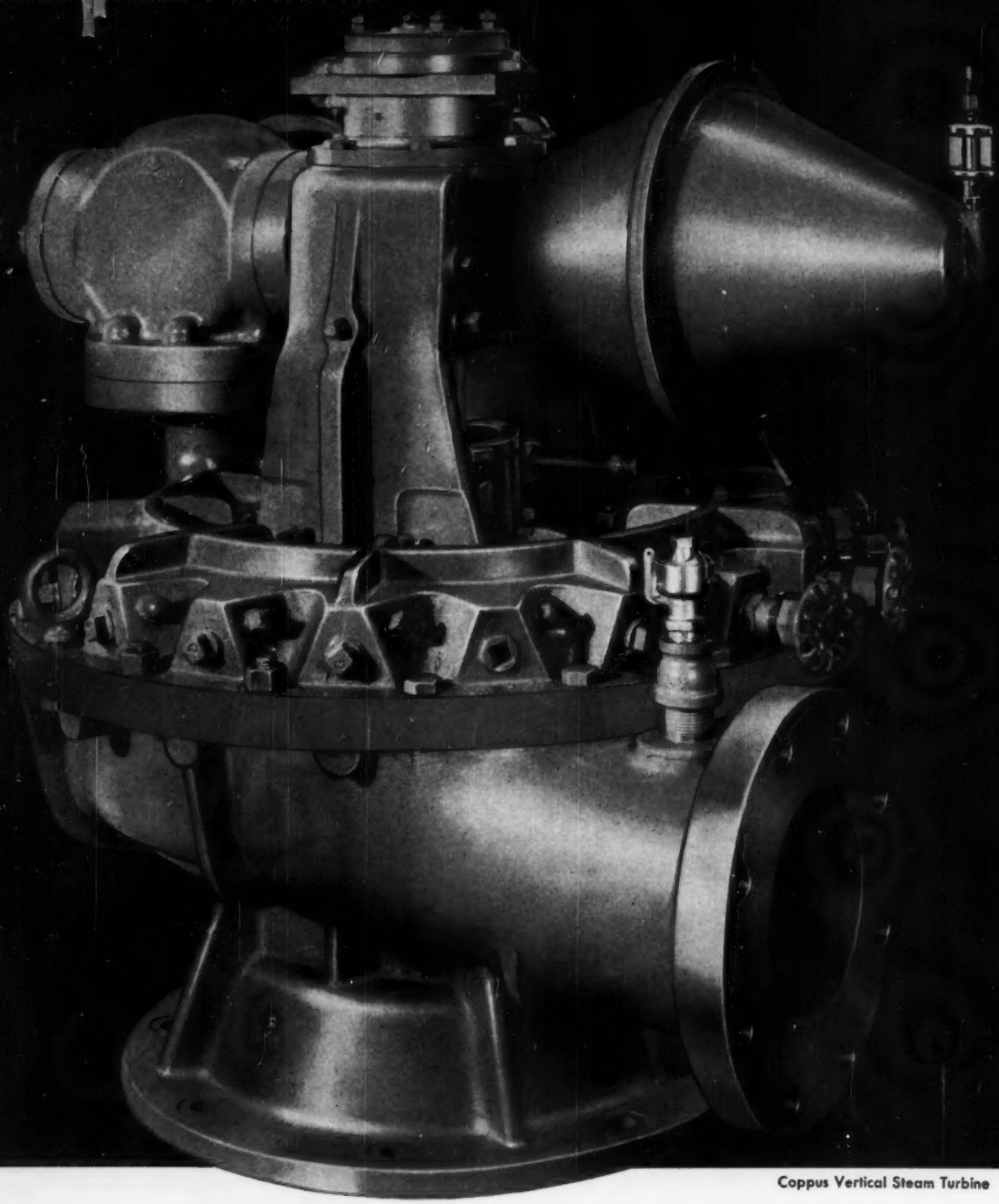
For more data on advertised products, use cards, last page.

COPPUS BLUE RIBBON PRODUCTS



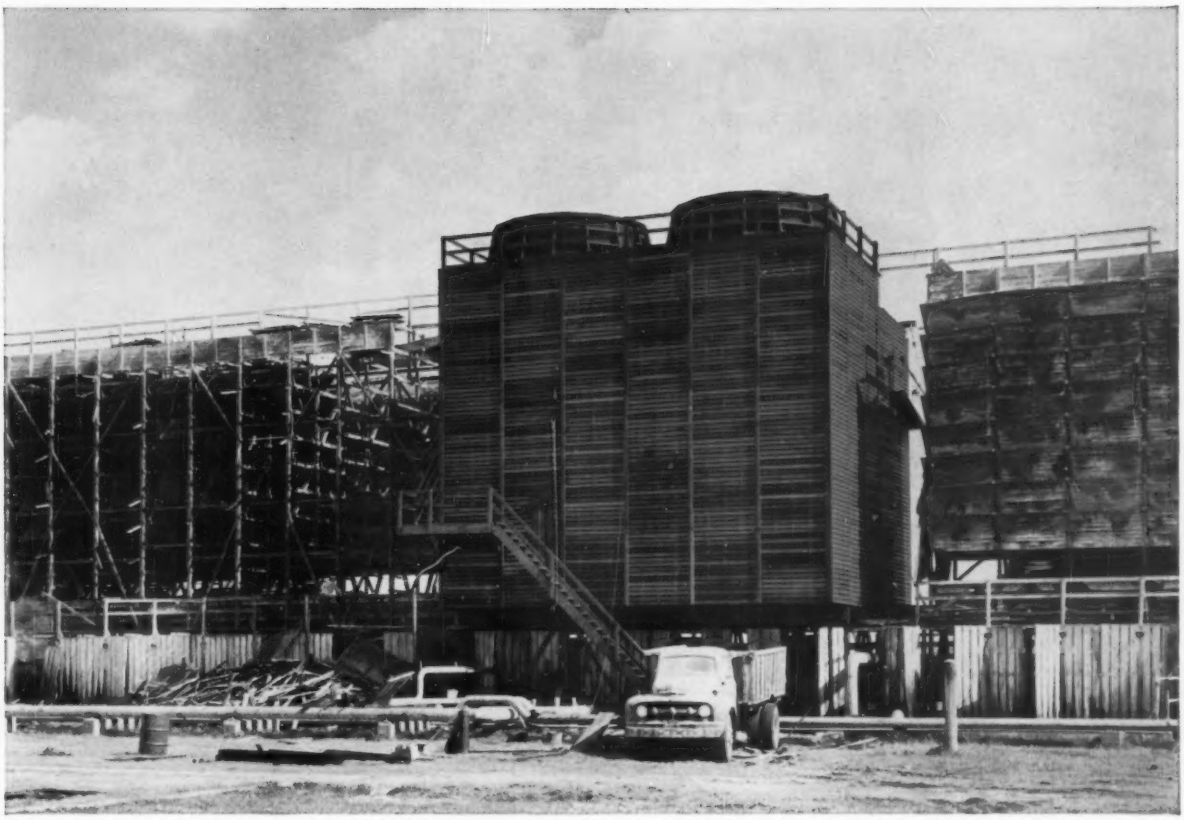
Coppus Vertical Steam Turbine

THE MARK OF QUALITY — There's no better test of a turbine's quality than performance. And the new, ruggedly designed, power-packed Coppus Turbines pass all performance tests with top honors! Small wonder. Coppus quality is literally designed and built into them. Their super stamina is the end-product of painstaking craftsmanship, finest materials and methods, thorough testing and control. Each truly deserves its Blue Ribbon . . . assurance of *complete* reliability.

Typical Coppus Blue Ribbon features are: *totally enclosed governor . . . totally enclosed and independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.* You get higher efficiency operation . . . less down time . . . lower maintenance costs.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Send for Catalog 200. Get complete details on Coppus Turbines. Sizes from 1 HP to 250 HP. Write COPPUS ENGINEERING CORPORATION, 419 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES



HUDSON EXPERIENCE IN COOLING TOWER REPAIR, REMODELING AND REPLACEMENT — ASSURES SPEED, SKILL, AND INTEGRITY

For instance the above pictured HUDSON induced draft tower, 36 feet long, was erected in the area and on the foundations formerly occupied by the mid sections of a 162 feet long deteriorated natural draft tower. Exposed-tube coolers in the base of the original tower were left in place, and cooled water from the new tower distributed over these coolers. The completed installation is shown below.

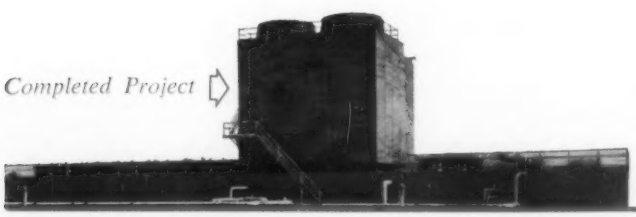
The work of dismantling, remodeling, and erection required 27 working days, and total shutdown time was less than 24 hours.

Although deterioration of the old tower necessitated its replacement, plant records show that increased revenue due to lower operating costs and greater product yield because of colder water, will give a *quick return of the investment.*

HUDSON maintains a cooling tower repair and replacement department staffed with experienced engineering and field personnel. Materials are stocked at HUDSON fabricating centers in California and Texas. If your cooling tower is *obsolete* or deteriorated avail yourself of HUDSON cooperation in developing the most economic replacement program.

In addition to water cooling towers HUDSON designs and manufactures SOLO-AIRE units (for cooling solely with air), and COMBIN-AIRE units (for cooling with combination of air and water). Only HUDSON is equipped to integrate these all-encompassing categories of equipment into cooling systems balanced to meet most economically specific conditions of climate, quantity and quality of water, and processing requirements.

Completed Project ⇨



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Bethlehem makes a special nut for every application: For use with Bethlehem continuous-thread studs, choose from these four grades of specially engineered nuts:

Grade 2—moderately high temperatures and pressures
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Each nut meets ASTM Specification A-194. And each comes in the full size range.

Bethlehem continuous-thread studs and quenched nuts are available for a wide variety of refinery applications. For more information call the nearest Bethlehem sales office, or write to us at Bethlehem, Pa.

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. . . Economy
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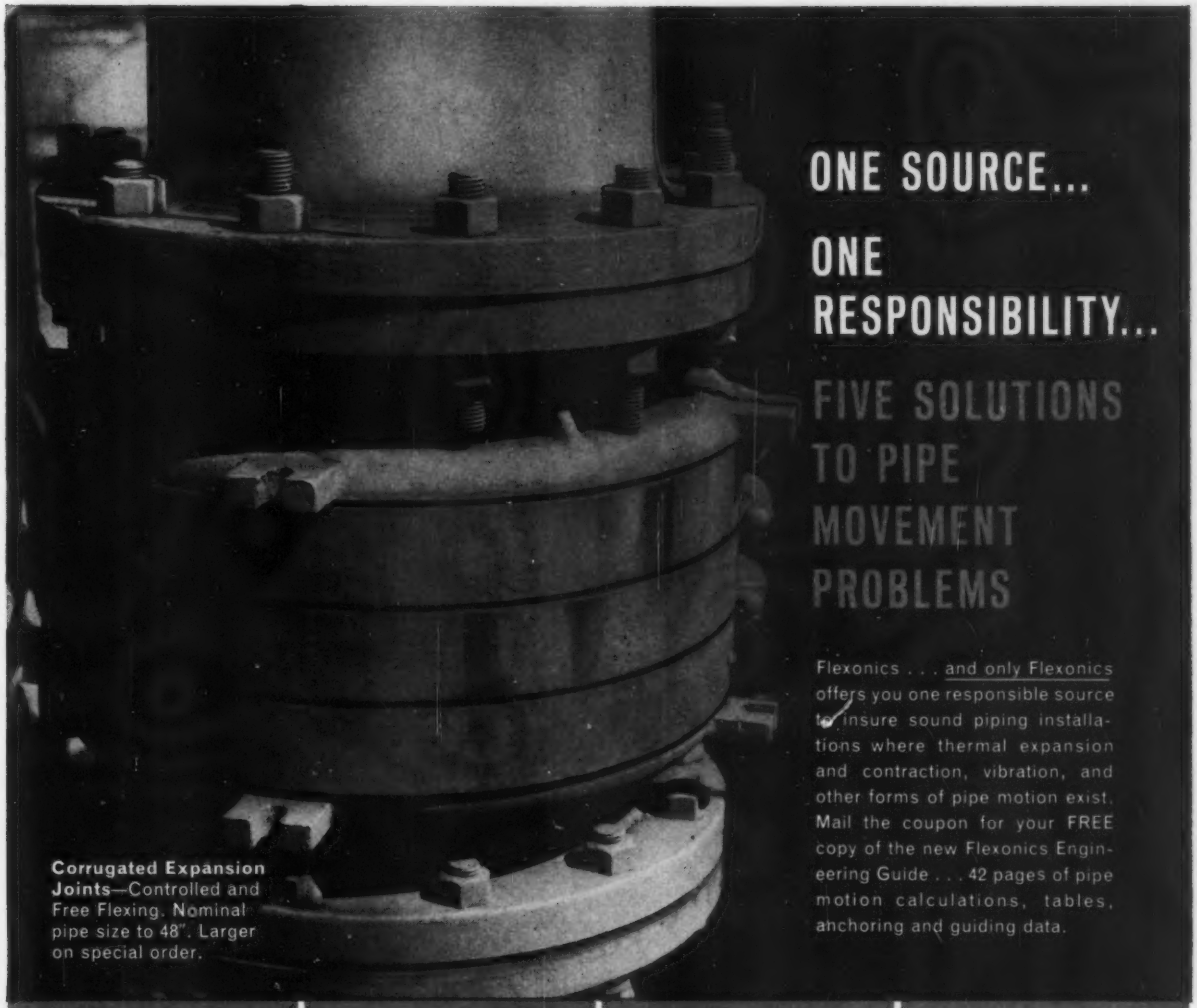

Corrugated Expansion Joints—Controlled and Free Flexing. Nominal pipe size to 48". Larger on special order.

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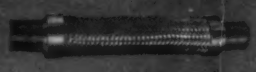
Flexonics . . . and only Flexonics offers you one responsible source to insure sound piping installations where thermal expansion and contraction, vibration, and other forms of pipe motion exist. Mail the coupon for your FREE copy of the new Flexonics Engineering Guide . . . 42 pages of pipe motion calculations, tables, anchoring and guiding data.

Expansion Compensators—Low and high pressure models. Available in steel, all stainless steel, and bronze.



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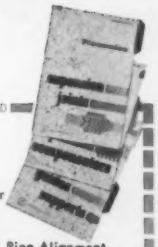

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Please send me Flexonics Engineering Guides and other information in the areas that I have checked:

- ☐ Flexonics Expansion Joints
- ☐ Pipe Alignment Guides & Supports
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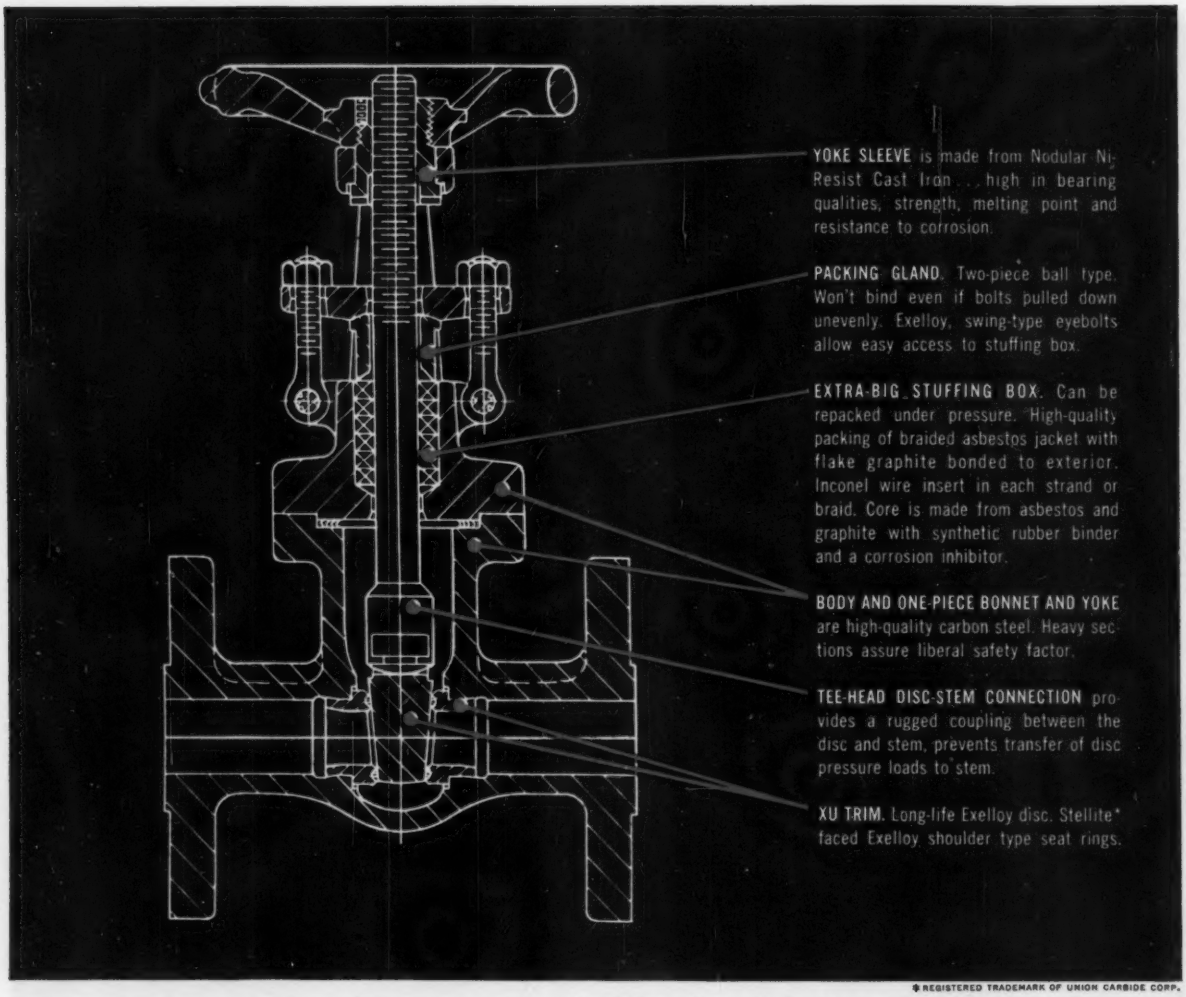
For more data on advertised products, use cards, last page.


YOKE SLEEVE is made from Nodular Ni-Resist Cast Iron . . . high in bearing qualities, strength, melting point and resistance to corrosion.
PACKING GLAND. Two-piece ball type. Won't bind even if bolts pulled down unevenly. Exelloy, swing-type eyebolts allow easy access to stuffing box.
EXTRA-BIG STUFFING BOX. Can be repacked under pressure. High-quality packing of braided asbestos jacket with flake graphite bonded to exterior. Inconel wire insert in each strand or braid. Core is made from asbestos and graphite with synthetic rubber binder and a corrosion inhibitor.
BODY AND ONE-PIECE BONNET AND YOKE are high-quality carbon steel. Heavy sections assure liberal safety factor.
TEE-HEAD DISC-STEM CONNECTION provides a rugged coupling between the disc and stem, prevents transfer of disc pressure loads to stem.
XU TRIM. Long-life Exelloy disc. Stellite* faced Exelloy shoulder type seat rings.

* REGISTERED TRADEMARK OF UNION CARBIDE CORP.

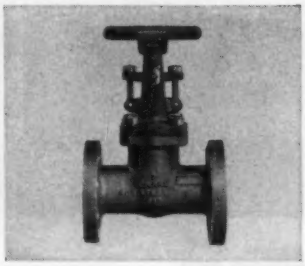
Crane adds flanged 150 & 300-pound steel gate valves to famous 3600 series.

Gives you a complete line of Small Steel Gate Valves suitable for all services at temperatures up to 1000 F. Available in sizes ½" to 2". Gives you design refinements generally associated only with higher priced valves.

The drawing illustrates only a few of the important features of these superior valves. There is built-in quality and reliability in every detail. Outside screw and yoke ruggedly constructed. Stem is heat treated Crane Exelloy. Bonnet joint gasket of spiral wound, Type 316 stainless steel with asbestos filler.

The cast steel 150 & 300-pound valves have "XU" trim and flanged ends (face-to-face conforms to ASA B — 16. 10) . . . figure numbers 3510XU (150 pound) and 3514XU (300 pound).

With the addition of these new valves to the 3600 Series, Crane now offers you the industry's finest choice of quality, small steel valves. All of them are ideally suited for use with steam, water, air, gas, oil, oil vapor, gasoline, fuel oil and similar services.



More details from your Crane distributor. Or write to Crane Co., Dept. T, Industrial Products Group, 4100 South Kedzie Ave., Chicago 32, Ill. In Canada: Crane Ltd., 1170 Beaver Hall Square, Montreal.

AT THE
HEART
OF HOME AND
INDUSTRY

CRANE

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HEATING • AIR CONDITIONING

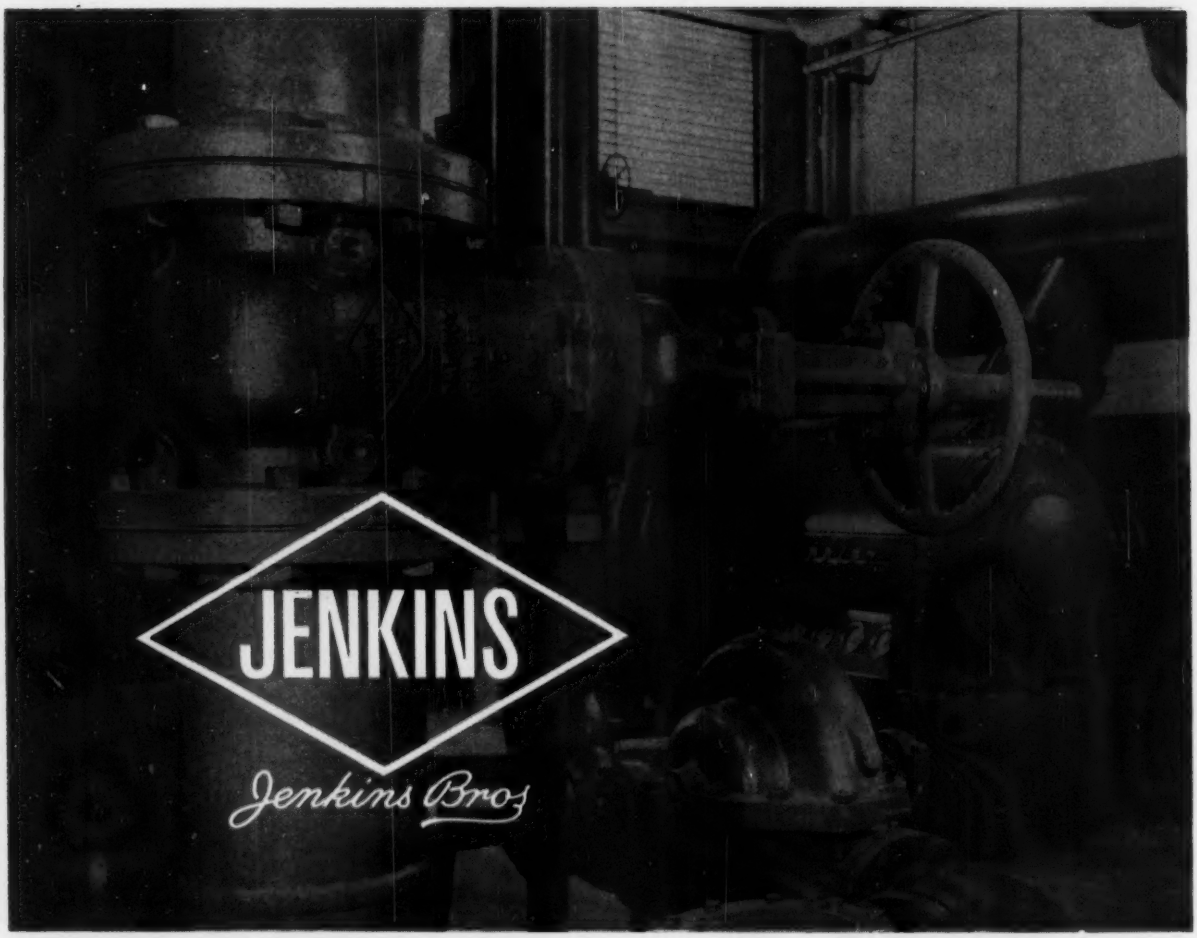
What's so special about the huge fractionating tower shown here? It is one more example of how Sun Ship builds and delivers heavy industrial equipment on barges or sea-going vessels, with careful attention to such requirements as safety and on-time schedule.

Whether it's a fractionating tower or key structural part for industry, transporting big items by water or by rail is strictly routine for Sun Ship, for we build and deliver what's needed in many fields. If you have a machinery or heavy equipment problem, write to us about it.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.



The Sign of a Real Bargain in an IRON BODY GATE

Cost-Per-Year is Lower... Initial Cost no Higher

For generations extra-quality, extra-stamina Jenkins Iron Body Gates were regarded as the best buy for the money . . . even though they cost more to buy. Lower maintenance expense and extra years of service more than offset any price differential.

Today, these widely favored valves are an even bigger bargain in true value. *You pay no more for them at the start!* And you get exactly the same high quality and perfection of design for your money.

You can satisfy all your needs from the complete line of Jenkins Iron Body Valves. Jenkins Bros., 100 Park Avenue, New York 17.

AVAILABLE FROM LEADING DISTRIBUTORS EVERYWHERE

JENKINS
MOST TRUSTED TRADEMARK IN THE VALVE WORLD
VALVES
JENKINS SINCE 1864
Jenkins Bros

IN FIVE PLACES AT ONE TIME...

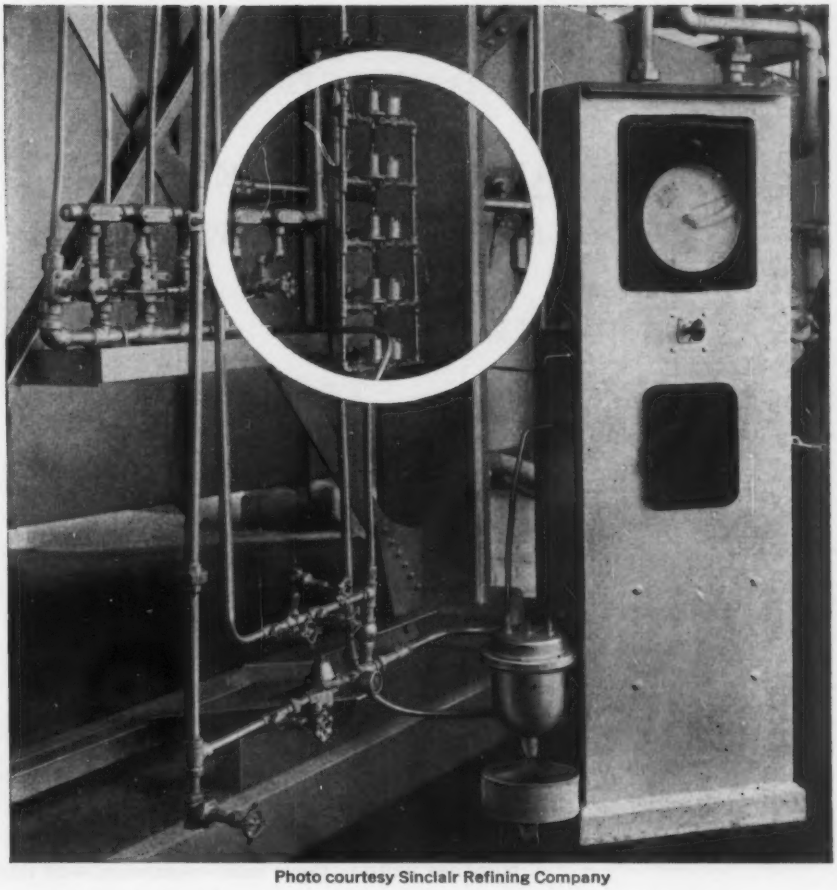


Photo courtesy Sinclair Refining Company

Multi-point sampling system solves oil-heater combustion control problem at a Houston refinery

To Insure top combustion efficiency and fuel economy, an instrument engineer will locate continuous gas analyzers and recorders at each individual furnace or heater.

Where combustion conditions vary widely, this practice is most desirable. But where conditions are relatively stable for long periods, the practice may not be economical . . . portable HEAT PROVER analyzers being sufficient.

At a Sinclair Refining Company installation in Houston, Texas, the problem lay between these extremes . . . and the solution is an interesting one.

The Problem: Five oil heaters were to be fired with natural gas or refinery gas, the latter switched in when available. Because of variations in BTU, a check on combustion was required to insure constant temperatures and efficient combustion. A study of operations indicated that the interval of checking was too short for proper use of HEAT PROVER analyzers yet too long to justify individual analyzers and recorders.

The Solution: A Bailey multi-point sampling system. It tied the five oil heaters to a single recording panel, automatically sampling each at a prescribed interval. A two-pen system records (1) per cent oxygen at each point, (2) the indentity of the heater measured. The system also provides a means of drawing gas samples from any heater at any time the operator wishes to recheck that station.

There are 13 other Bailey analyzers at this Sinclair refinery.

A Bailey Engineer will be glad to explain how this and other advanced Bailey instruments and controls can help you toward greater processing efficiencies. Refer to your phone book for the Bailey District Office, or write direct to our Chemical and Petroleum Division.

CP 109-1

CHEMICAL AND PETROLEUM DIVISION

BAILEY METER COMPANY

1043 IVANHOE ROAD • CLEVELAND 10, OHIO

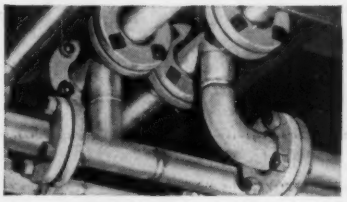
In Canada—Bailey Meter Company Limited, Montreal

For more data on advertised products, use cards, last page.

DON'T BE HANDICAPPED BY OUTDATED SPECIFICATIONS!

YOU CAN SAVE MONEY ON PROCESS PIPING SYSTEMS!

IMPROVED FITTINGS DESIGN AND NEW PIPING STANDARDS CUT COSTS!



The ultimate installed cost of corrosion-resistant process lines *can* be substantially reduced . . . where pipe line design specifications take full advantage of up-to-date developments in improved fittings design and new piping standards.

The most recent issue of the Code for Pressure Piping, ASA B31.3-1959, allows use of *light wall* Stainless Steel Schedules 5 and 10 pipe and fittings for critical process lines to a degree not possible with *outdated* specifications. The broader scope of pressure-temperature operating conditions included in this new code, permits computations utilizing these more economical wall thicknesses. This, plus a specification recognizing the efficiency of Speedline fittings, guarantees a soundly designed system at a *lower* installed cost.

Every Speedline fitting has built-in advantages that contribute to lower installation cost because they are designed especially for use with light wall Schedules 5 and 10 pipe. Speedline's extra length feature means butt joints are easier to align and easier to weld because you're always connecting "straight to straight". There's ample clearance to attach flanges to any or all ends of a Speedline fitting without fouling—by expanding or welding. Speedline aligning connectors assure sound socket-joining for both pipe and fittings. With Speedline—*one fitting* does it all. Review your process piping specifications to be sure they call for all of the cost savings possible with light wall pipe and modern Speedline fittings.

Speedline®

CORROSION-RESISTANT FITTINGS

STAINLESS STEEL • ALUMINUM • SPECIAL ALLOYS

100

A PRODUCT OF **HORACE T. POTTS COMPANY** • 566 E. ERIE AVENUE, PHILADELPHIA 34, PA.

GO-DEVIL... first rig to offer refineries new ideas in maintenance, construction, rigging

Speed and mobility are essential to meet tight schedules during maintenance or expansion of a petroleum plant. Drott's 6,000 lb. capacity hydraulic crane is the first new rig to offer the refinery new methods for maintenance, construction and rigging.

The Go-Devil features a full length side carrydeck (26″ wide) capable of transporting pipes or columns to any length. Total carrydeck capacity is 50 sq. ft. and 8,000 lbs. Low profile of 8′5″ (other models as low as 7′5″) permits you to clear low overhead pipes and get close to maintenance problems. Rear-wheel steer and front-wheel drive combined with a compact 74″ width also gets you in and out of tight spots.

The hydraulic boom telescopes out to 24′ to precisely spot pumps, compressors, valves, gear boxes, pipe. And it rotates in a constant 360°.

Why get a larger more expensive unit when you can trust the versatility of the Drott 60 RM2 Go-Devil with your jobs? Fill out the coupon below now. *Ask about the 45 RF2 and 20 RR2 Go-Devils, too!*

IT REACHES	IT LIFTS	IT SWINGS	IT TRAVELS	IT HAULS
24′ up . . . 16′ out	6000 lbs. with safety	360° continuous rotation	up to 19 MPH	on 50 sq. ft. of deck area

DROTT
MANUFACTURING CORP.
Milwaukee 15, Wisconsin

CLIP AND MAIL TO

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Materials Handling Division
3126 S. 27th Street • Milwaukee 15, Wisconsin

I'd like more information on the 60 RM2 Go-Devil.
Please rush bulletin MH603.

Name.....

Title.....

Company Name.....

Company Address.....

City..... Zone..... State.....

For more data on advertised products, use cards, last page.

Pennsalt service helps you cash in on HYDROFLUORIC ACID alkylation

The striking savings you can get when you alkylate with hydrofluoric acid are a matter of record. And Pennsalt's long, specialized experience with AHF can help you take advantage of these savings. We'll show you how to handle, store and use Pennsalt AHF safely and confidently . . . advise you on valves, pumps, piping and materials of construction . . . help you with employee training programs . . . give you personalized technical assistance tailored to your needs. Ask your Pennsalt representative, or write for full information. Industrial Chemicals Division, PENNSALT CHEMICALS CORPORATION, Three Penn Center, Philadelphia 2, Pa.

- Lower catalyst cost
- Shorter reaction time
- Faster catalyst settling
- Reduced acid inventory
- Lower cooling expense
- Minimum spent acid problems
- Minimum side reaction products

New HF Handling and Data Book. Includes text, drawings, graphs, tables, photos. Write for Bulletin S-148.

See our complete listing in Chemical Materials Catalog

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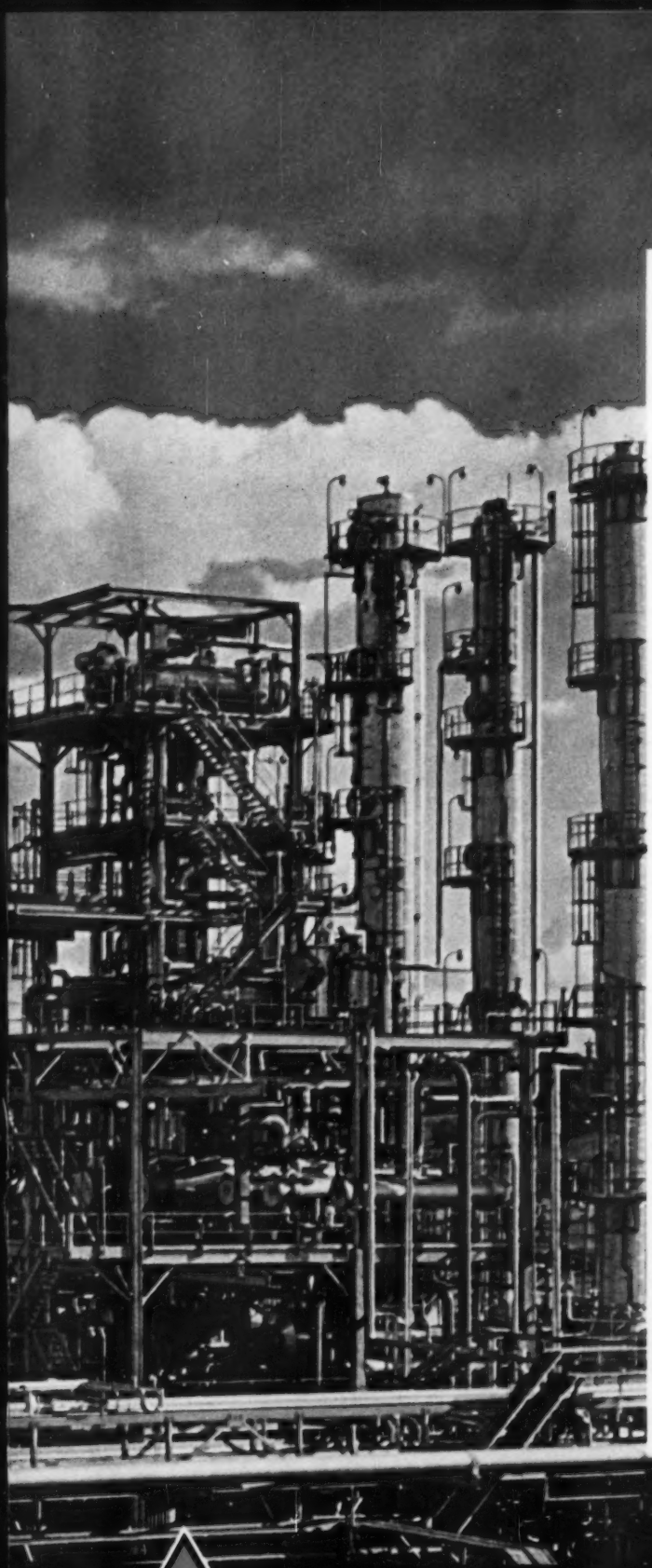
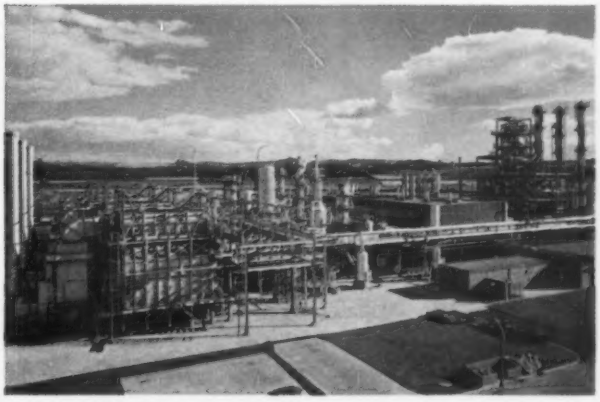


STONE & WEBSTER CONSTRUCTS A SCOTTISH GIANT

FOR BRITISH HYDROCARBON CHEMICALS LIMITED . . .

Completed ahead of schedule in June, 1960, Number 3 Ethylene Plant for B. H. C. at Grangemouth, Scotland was designed and constructed by Stone & Webster Engineering Limited. The new plant is one of the largest ethylene units outside the United States.

The plant employs the Stone & Webster process reflecting cumulative experience gained over a period of years from the design of over 36 ethylene plants processing a wide variety of feed stocks. Maximum stream time, heat economy, simplicity of operation and minimum maintenance are basic to this process. We would welcome the opportunity to review how our skills and experience could prove profitable to your next engineering project.



STONE & WEBSTER ENGINEERING CORPORATION

AFFILIATED WITH STONE & WEBSTER ENGINEERING LIMITED (LONDON)

New York, 90 Broad Street Boston, 49 Federal Street Chicago Houston San Francisco Los Angeles Seattle Toronto Calgary

is Creep affecting your high-temperature operations?

The container for heavy liquids at high temperatures, shown above, is a striking example of creep failure. Note the "necking down" below the supporting lip and the bulging of the container near the bottom.

Creep is a time-dependent plastic flow occurring under stress, usually at elevated temperatures. In a creep-rupture test, three distinct stages are observed. The initial stage has a relatively high, but steadily decreasing creep rate. In the second stage, the rate is constant and provides the minimum rate of the entire test. The creep rate in the third stage increases steadily to rupture.

Creep is but one of five major failure mechanisms that can affect your high-temperature operations. The others are oxidation, thermal fatigue, carburization and phase change. Any one or a combination of these mechanisms can result in reduced service, frequent repair or costly replacement of your high-temperature equipment.

You should, therefore, select suppliers who are aware of these failure mechanisms, so that they can assist you in selecting a material and a design that will insure longer life and more dependable service.

Here at Electro-Alloys and at our Research Center in Mahwah, New Jersey, we have studied in detail the significance of all of the failure mechanisms as they relate to metal composition, design, service conditions and manufacture of heat-resistant alloy castings.

Our Research Center, for example, pioneered the establishment of a creep laboratory and has played a major role in defining the variables affecting validity and precision in creep-rupture testing.

From these studies, we have developed new high alloys for use in heat-resistant castings. But more important, we have become better qualified to assist you in getting maximum life and reliable service from high-temperature equipment.

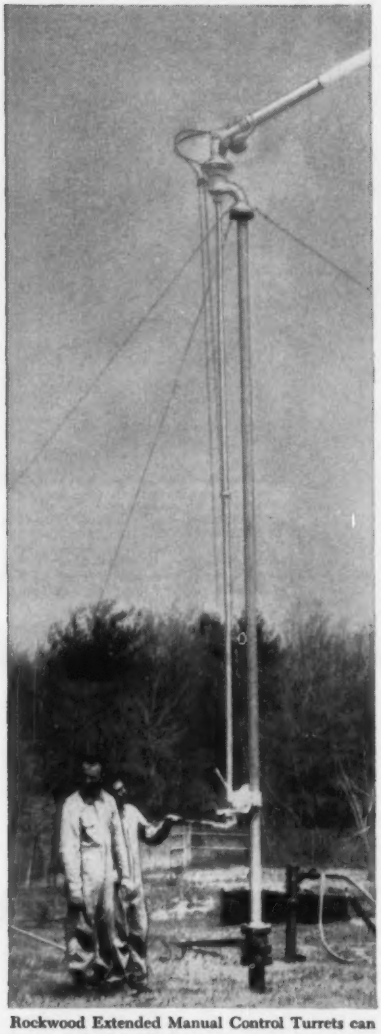
Our local sales representative will be happy to discuss any of your problems concerning heat-resistant applications. Please feel free to call on him.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

Fight fires from any angle...
WITH ROCKWOOD SPECIALTY TURRET NOZZLES

Getting The Upper Hand...



Rockwood Extended Manual Control Turrets can be located 10 to 20 feet above a remote control station on the ground. Greater discharge range increases their fire fighting coverage. Higher extensions are engineered for special applications.

On the ground, on trucks, or towering over the flames, Rockwood Turret Nozzles are valuable fire fighting aids for use in refineries and chemical plants.

In fact, Rockwood makes the most complete line of specialty turret nozzles on the market. Every type is designed to fight fire four ways: with solid FOAM stream, FogFOAM, WaterFOG or solid water stream. And all are easily adjustable to meet changing fire conditions.

Throughout the country these Rockwood advancements are proving they can hit fires harder and faster. Find out how well they can protect your own plant. For an illustrated booklet on this complete line, write to Rockwood Sprinkler Company, Portable Fire Protection Department, 503 Harlow St., Worcester 5, Mass.

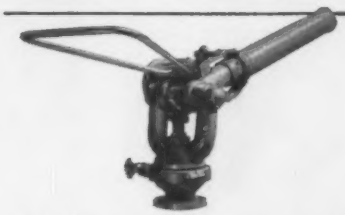
ROCKWOOD SPRINKLER COMPANY

A Division of The Gamewell Company
A Subsidiary of E. W. Bliss Company

Engineers Water
...to cut fire losses

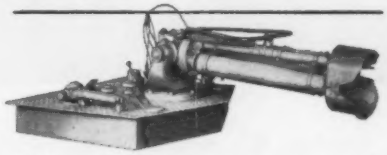
Distributors in all principal cities

Fighting Fires Four Ways

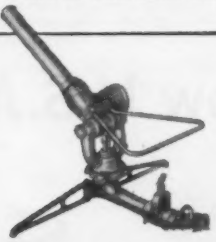


Rockwood Direct Manual Control Turrets give fire fighters "on deck" control from their cab roofs.

A Remote Manual Control Turret is easily handled by a man in the driver's seat. Ideal for fast action.

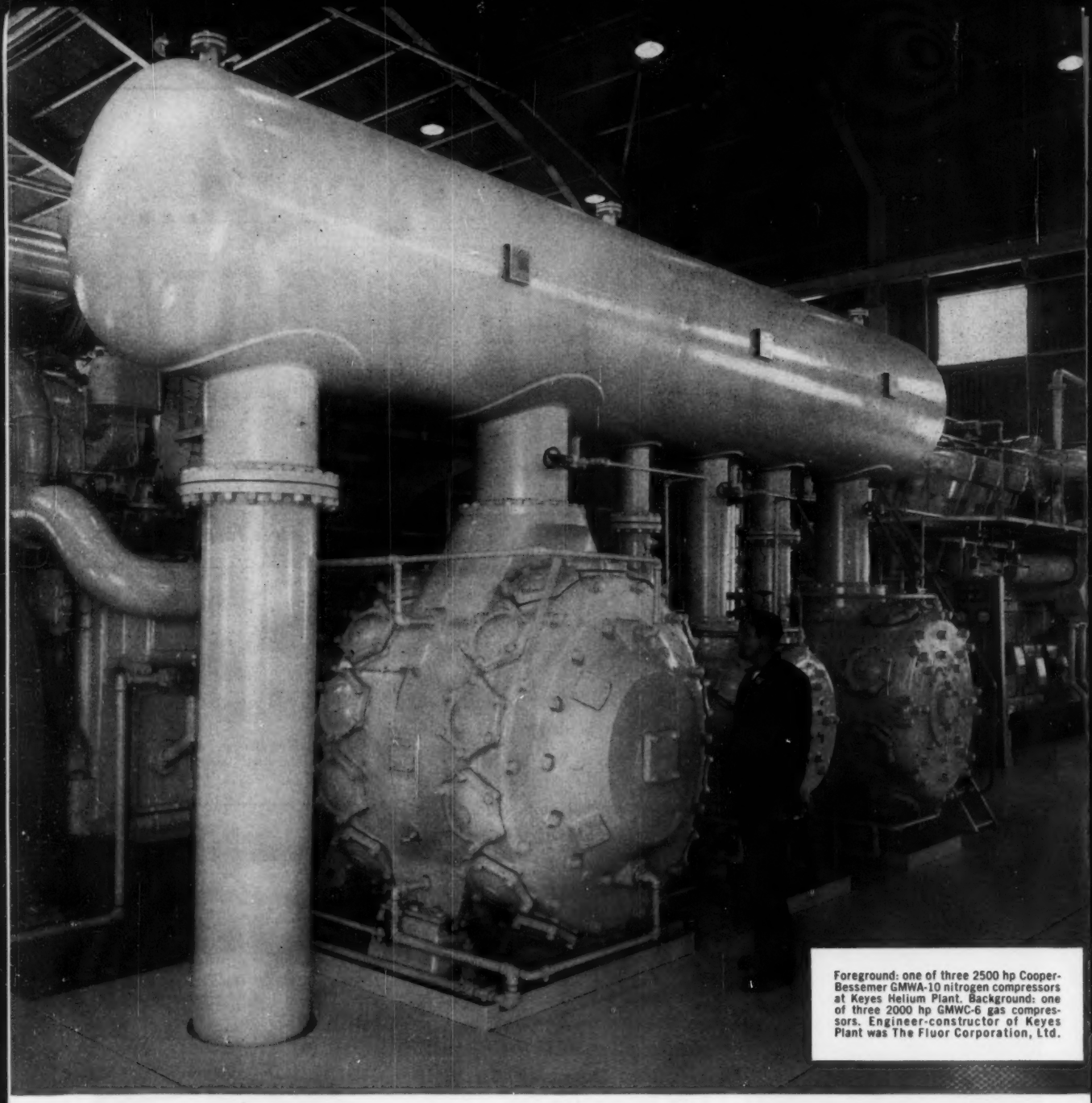


The Remote Hydraulic Control Type, single or dual model, is power controlled from within the cab. Widely used on crash rescue trucks.



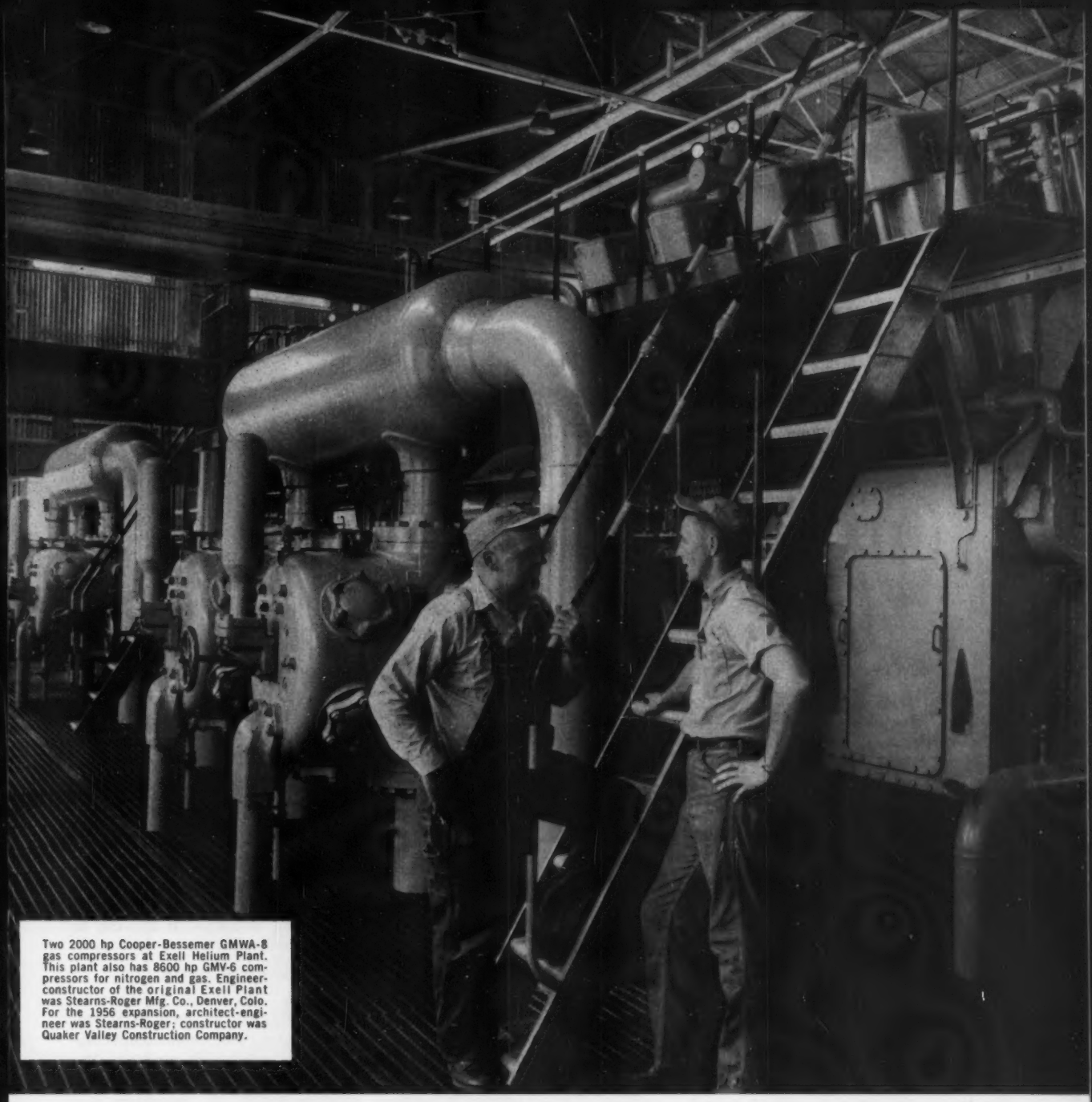
The Portable Type goes off the truck and into action in seconds – wherever hose lines can be brought into action.

For more data on advertised products, use cards, last page.



Foreground: one of three 2500 hp Cooper-Bessemer GMWA-10 nitrogen compressors at Keyes Helium Plant. Background: one of three 2000 hp GMWC-6 gas compressors. Engineer-constructor of Keyes Plant was The Fluor Corporation, Ltd.

How U.S.A. puts the squeeze on its helium



Two 2000 hp Cooper-Bessemer GMWA-8 gas compressors at Exell Helium Plant. This plant also has 8600 hp GMV-6 compressors for nitrogen and gas. Engineer-constructor of the original Exell Plant was Stearns-Roger Mfg. Co., Denver, Colo. For the 1956 expansion, architect-engineer was Stearns-Roger; constructor was Quaker Valley Construction Company.

The job of extracting helium from natural gas is a low-temperature process in which compression plays a key part. And that's where Cooper-Bessemer horsepower comes in . . . in a big way.

At our country's two principal existing helium plants—the Exell Plant near Amarillo, Texas, and the Keyes Plant at Keyes, Oklahoma—Cooper-Bessemer gas engine compressors play key parts in both of the basic, heavy-duty compression operations for helium extraction . . . compressing nitrogen for refrigeration and boosting pressure of natural gas for return to supply lines.

At Exell, built during World War II and expanded in 1956, ten C-B compressors total 8,800 hp.; at Keyes, completed in 1959, six total 13,500 hp. All of the Cooper-Bessemer units in both plants are giving reliable service, 'round-the-clock in the production of this highly important inert, lightweight gas for industry and the U.S. defense program.

Call our nearest office for information on C-B products for *your* compression and power facilities.

BRANCH OFFICES: Grove City • New York • Washington • Gloucester Pittsburgh • Mount Vernon • Detroit • Chicago • Minneapolis • St. Louis Kansas City • Tulsa • New Orleans • Shreveport • Houston • Greggton • Dallas Odessa • Pampa • Casper • Seattle • San Francisco • Los Angeles
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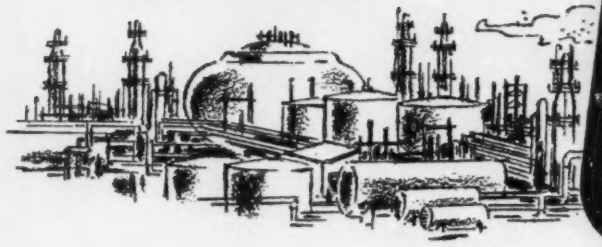
JET-POWERED GAS TURBINES

Portable MINIMITE® Goes Anywhere

for Accurate Temperature – Millivolt Measurement



Take accurate temperature-millivolt measurements wherever you go—laboratory, plant or field—with the rugged, compact, portable "MiniMite". Moderately priced, the "MiniMite" (null-balance potentiometer pyrometer) weighs just 3½ lbs., measures just 4″ x 5″ x 6″, provides ¼ of 1% of scale accuracy with a long 23.6″ double range scale. Widely spaced scale graduations facilitate easy, accurate reading. A standard flashlight battery provides standardization.

Measure Temperatures Directly

Connected to a thermocouple, the "MiniMite" provides accurate temperature indication, anywhere. It is used for standard checking and calibrating procedures. Automatic cold-junction compensation is built-in.

Measure Millivolts Directly

Any transducer with a dc millivolt output can be checked quickly with the "MiniMite".

Calibrate Other Instruments

The "MiniMite" can be used to check or calibrate potentiometer or millivoltmeter type recorders, indicators, controllers, easily—with little or no extra equipment.

Special Design

An adaptation of the "MiniMite", called the Airline "MiniMite", is made to quickly check dynamic performance characteristics of jet engine exhaust temperatures, E.G.T. spread or average and calibrate cockpit indicators. It also can be used as a source of variable dc millivolts.

72 Double Range Scales

Range Scales for the "MiniMite" can measure temperatures from minus 450°F. to plus 3200°F. with all standard thermocouple materials, including various Platinum-Rhodium combinations. Many millivolt scale ranges are available. The double range scales are available with two different thermocouple calibrations, combinations of a temperature and millivolt range, or a single temperature or millivolt scale.

Operation Is Easy

Anyone can obtain accurate readings quickly. Connect the "MiniMite" to a sensing element or instrument to be checked, standardize and adjust for readings.

You can have delivery of the model, and range scales you need promptly, many are carried in stock.

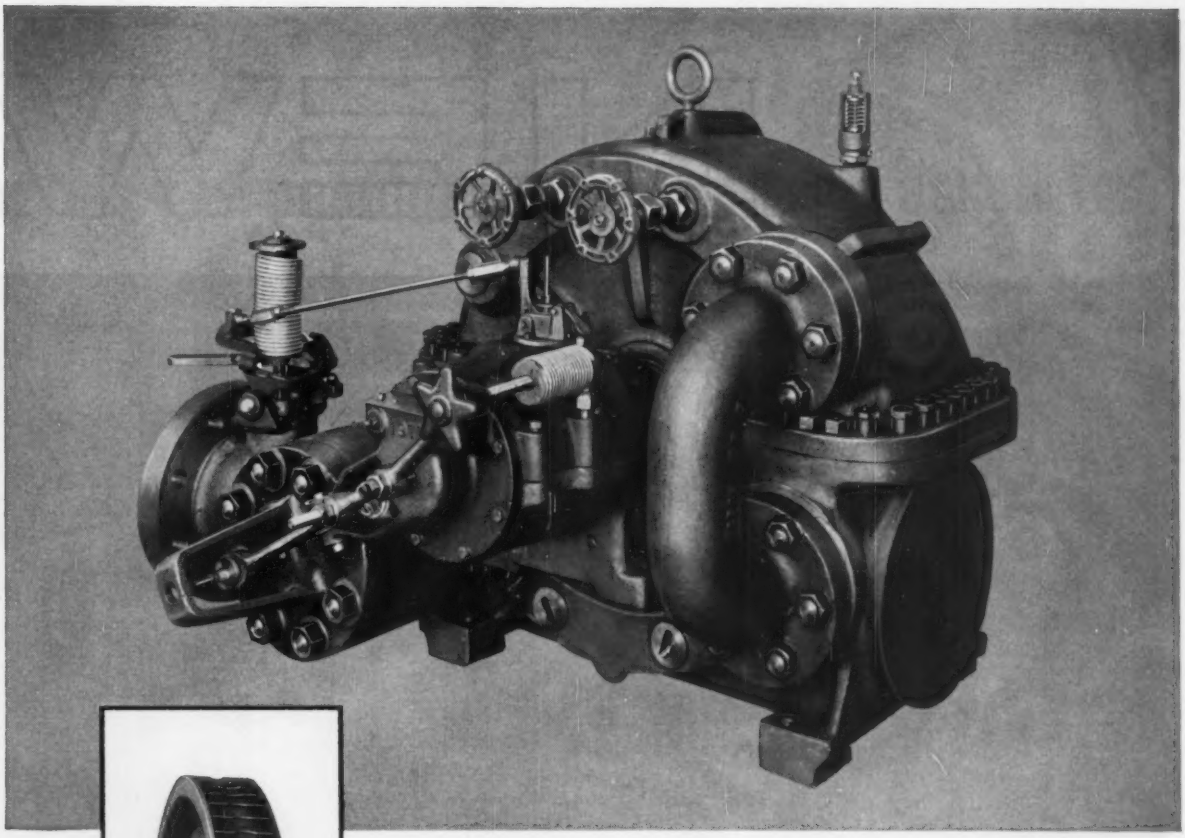
Write today for information—Instrument section 64-19

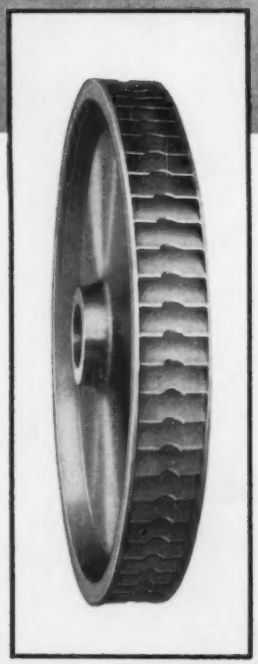
Thermo Electric

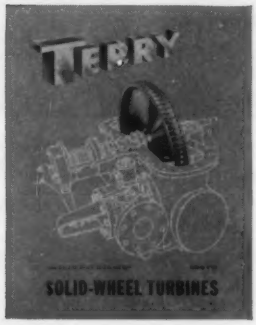
Temperature Measuring Systems and Components

20 YEARS

THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.







solid-wheel turbine means performance instead of worry

In these days of automated production, proven reliability has come to be highly prized in a machine. That fact helps to explain the popularity of the Terry solid wheel. For here is a turbine designed from the start to be solid and simple . . . require minimum maintenance.

The wheel is a single steel forging. Unlike a built-up rotor there are no separate parts to loosen or work out. Since the effective steam action is at the backs of the buckets, wear does not affect efficiency.

Blades are notched in the centers to prevent destructive forces from being built up at the corners. The blades can't foul. They are protected at both sides by heavy rims and large clearances.

When you need continuous service, year in and year out, insist on Terry solid-wheel turbines.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

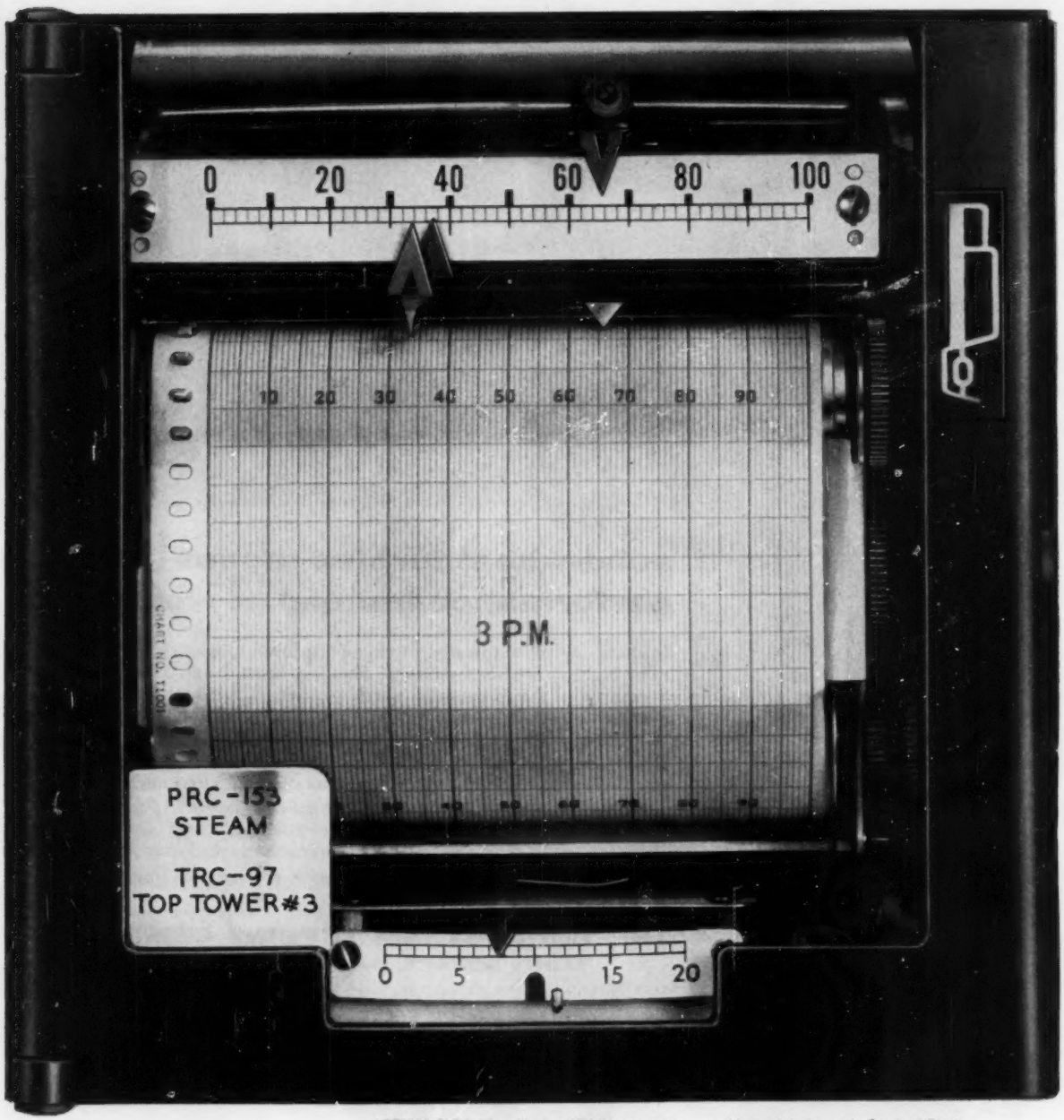
TERRY

SEND FOR THIS NEW BOOK!
Discusses in detail the design and performance of the Terry solid-wheel turbine. Ask for bulletin S-159.

TT-1222

For more data on advertised products, use cards, last page.

NEW..



ACTUAL SIZE. New Series 670 Metagraphic is ideal for graphic panel applications, occupying panel space only 7" wide by 7⅛" high. Fits into 6" by 6" panel cutout. Typical 670 Series models available, include:

- 1-Pen, 2-Pen, or 3-Pen Receiver
- Manual-Automatic Control Station
- Manual-Cascade Control Station
- Manual-Automatic-Cascade Control Station
- Single-Case Cascade Control Station

here's the pneumatic receiver you asked for!

Bristol's new 4-inch-chart Metagraphic receiver

is the easiest yet to install, operate, and service

Never before has a 3-15 psi pneumatic receiver been designed with such exacting, meticulous attention to the needs of the graphic panel designer, the instrument user, and the instrument maintenance man.

Bristol's new Series 670 Metagraphic receiver brings you the plug-in versatility and operating convenience—made famous in previous Metagraphic pneumatic receivers—plus the increased legibility and accuracy of a 4-inch strip chart, plus these big new features:

Simplified control switching between functions... allows the easiest start-up procedure for either the common manual-automatic station or the more complex, single-case cascade control station models. Intermediate "seal" position has been eliminated. Just adjust process to line-up color-coded indicators and switch to automatic or cascade operation as desired.

Uniform control switching . . . all receiver models have the same switch positions for the various types of control —cascade position, 3 o'clock; manual position, 6 o'clock and automatic position at 9 o'clock.

Simplified chart change and inking . . . chart changing is a one-hand operation. A new chart can be slipped into place in an instant. The capillary inking system can be refilled from the front of the receiver.

And the new Metagraphic receiver gives you other outstanding features such as rectilinear chart coordinates for easiest reading, easy connections for any type of control, either field or receiver-mounted controllers; and sparkless, mercury-switch disconnect of electrical circuit when chassis is removed.

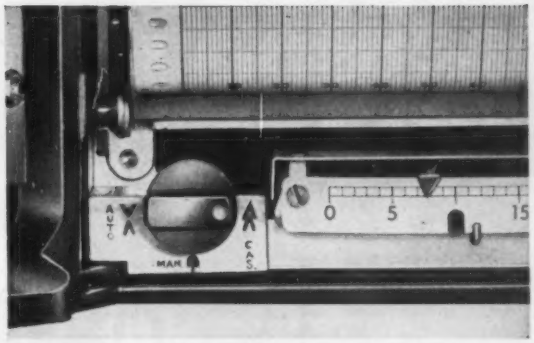
Get the complete story on the new Bristol Metagraphic receiver today. Write The Bristol Company, 111 Bristol Road, Waterbury 20, Conn., a Subsidiary of American Chain & Cable Company, Inc. 0.42

ACCO

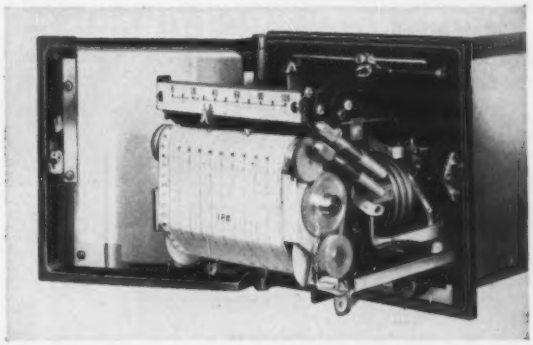
BRISTOL

...for improved production through measurement and control

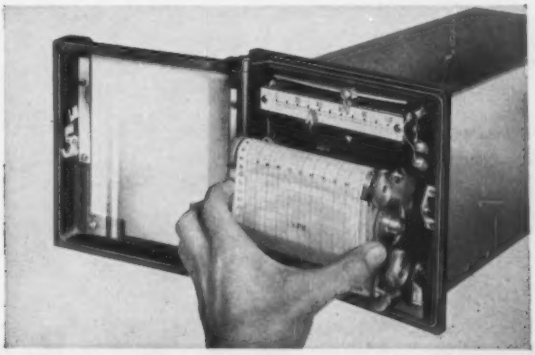
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



Simplified control switching is keynote of new receiver's design. For instance: uniform switch positions on all models avoid operator confusion in multi-receiver installations; simple alignment of color-coded pointers and a single switching operation put complex automatic or cascaded systems "on stream."



Complete "plug-in" service continuity. Entire plug-in receiver chassis is instantly replaceable with spare for complete continuity of service. Control functions are not disturbed when receiver chassis is removed.



Easiest to service . . . For instance: Easily removable chart drive mechanism—a one-handed operation—permits exceptionally fast chart replacement; just slip out drive, replace with spare, replace paper in original drive at leisure.

ONE OF A SERIES OF CHATS ABOUT THE CONSERVATION AND CONTROL OF HEAT

SARCO TOPICS

WHY THE BIG STRAIN?

It's tough to keep gases and liquids "clean" as they run through a pipe. They drag impurities along, which can make even plain water a trouble maker, let alone more sophisticated fluids. That's because water, as a liquid or steam, is intimately involved with vital equipment like steam traps, temperature regulators, or tools. Meters, burners, nozzles, and pumps, too.

By this time you must realize we're going to talk strainers, don't you? A good, stout subject, of interest to all who feel production belongs up and costs belong down. Sarco makes strainers for water and condensate, steam, oil, air, gas and other piped fluids . . . dozens of different sizes and types and ratings of strainers to match every application need. Even our line of plain and simple strainers is built for super service. These are pipeline strainers, types AT, BT, and CT, which are designed for 250, 250 and 600 psi non shock, respectively, and 475°, 450° and 750°F. temperature ratings. Standard screens are heavy-gauge, perforated brass or stainless steel. Sarco specializes in screens that can withstand abnormal pressure differentials created by accumulated sediment.

Next, Sarco's flanged strainers, type D. These come in larger sizes, right up to 12", and are available in standard or extra heavy types.

And finally, *Sarco scraper strainers*, manual or motorized. These are the really eye-popping models, and if you can't use one yourself — well — you'll just have to get your kicks elsewhere.

Examples? Take Inland Steel Company at East Chicago, which gets water from Lake Michigan to cool its large air conditioner condensers. The water used to pass through traveling screens, but still contained fine sand. Clogging!

Heat under collars! Frequent cleaning required! Sometimes practically no air conditioning on hot days. (Isn't that always the way?)

The Inland Steel people installed Sarco Rotary Scraper Strainers, Type VRS, which incorporate a hand-operated helical scraper knife within the cylindrical strainer screen. A few turns of the crank at regular intervals, and the sand is scraped off the screen, blown clear, and discharged at pressure through a manual valve to waste. Dismantle the strainer? Shut down the unit? Not *this* strainer!

Now, as long as we've come this far, it's only a hop and a skip to the Firestone Tire and Rubber Co. in Akron, Ohio, who also use water in tremendous quantities. They circulate it through tire presses and a cooling tower, and there's no nonsense about it. It *has* to be clean or damage to equipment could be downright catastrophic. When the plant

modernized and enlarged, Firestone replaced their 4" Sarco hand-operated scraper strainer, type VRS, with a larger Sarco 8" model. And while they were about it, they got the motor-operated type, for continuous cleaning.

When we say that companies like these want the insurance of a Sarco strainer, it sounds like advertisingese, but sometimes there just isn't any other way to put it. Sarco strainers *are* insurance at low cost on the operation of your high cost equipment. So when we ask if you have lumps in your pumps, or worries over your slurries, we're *serious*. We've heard everything in the straining line, so why not write us for literature and answers to those special problems you have.

A T-44 IS THE BEST POLICY

Sorry, but we can't leave the subject of insurance without bringing to your attention one of the best little insurance policies any company requiring cooling control could invest in. It's the *self-powered* Sarco T-44 Automatic Cooling Control. No compressed air or electricity is needed, but its advantages are best described in terms of three different plants of just one Sarco customer — Revere Copper and Brass, Inc.

Revere-Baltimore, Md., has cut water use 40 to 50% with T-44's. But in addition to former water waste, Revere had even more problems: possible wet air from uncontrolled cooling of compressor aftercoolers, plus sweating compressor cylinders; variations in viscosity of hydraulic oil and bearing oil; gas generator water waste; unreliability of manual shut-off of water supply when machines were down.

If your ears perk up in sympathy at mention of any of these problems, the results of Revere's cooling control program should bring you to full attention. One large compressor that had gulped 2400 gallons per hour now takes only 420 gallon sips. In addition all the problems itemized above were solved. T-44's are now used on their air compressors, gas generators, and hydraulic oil systems. At Revere-Riverside, Cal., water savings of 50% were experienced, and at Revere-Rome, N.Y., substantial savings were made too.

But after all, wasting water is only one way of wasting money, so let's go on to another matter of interest: the evils of manual control. When cooling water is controlled by hand the temptation to leave the valve nearly wide open is almost overpowering, in order to play it safe if the load varies. Result: overcooling, of course. And varying the flow runs the risk of undercooling. In either case, lowered process efficiency. Answer: The automatic Sarco T-44, which can't be tempted, is meticulously honest, unsentimental, and plain inhumanly practical when it comes to cooling control. You really ought to write for literature. T-44 is your best policy.

SPARE PARTS INSURANCE

As long as we're near the end, and still on this subject of insurance, may we graciously leave you with this valuable tip? No matter how closely a steam trap approaches perfection, some gremlin may cause it to act up. It's conceivable. So, keep on hand a parts list and spares of key parts for your steam traps and other system components. Parts are small and worth their weight in gold when you need them. A Sarco field engineer will make up a suggested list for you, if you tell us what components make up your system.

Might as well even keep a disc or two on hand for your Sarco Thermo-Dynamic Steam Traps, Type TD-50, even though they're so trouble-free our salesmen keep complaining about the lack of replacement parts business. We'll be glad to tell you about this unique steam trap in case you still don't know how miraculously simple and effective it is.

Pardon our monopolizing the conversation in this series of paid communiques, but we're trying our best to interest you in certain subjects that concern us both — to the point where you'll communicate.

5903

SARCO

SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.

STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

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A BRAND FOR EVERY SERVICE

GUNNING	RAMMING	CASTING*
	Corundum Ramming Mix	
	Korundal Ramming Mix	
	Coralite Ramming Mix Coralite Plastic Refractory	H-W Lightweight Castable 33
Castolast G	H-W Mullite Ramming Mix H-W Mullite Plastic Refractory	H-W Castolast
Apache Gun Clay	Apache Plastic Refractory	H-W High-Alumina Castable
H-W Chromepak H-W Super Gun Clay	Apachite Plastic Refractory H-W Super Plastic Fire Brick	H-W Lightweight Castable 30
H-W Harcast BF	Coral Ramming Mix H-W Black Patch	
H-W Kuplomix H-W Standard Gun Clay	H-W Standard Plastic Fire Brick	H-W Lightweight Castable 28 H-W Harcast
		H-W Super Castable
H-W Harchrome G		H-W Chrome Castable H-W Harchrome Castable H-W Lightweight Castable 26 H-W Extra Strength Castable LI
		H-W Standard Castable H-W Baffle Mix
		H-W Extra Strength Castable
		H-W Lightweight Castable Extra Strength
		H-W Low-Iron Lightweight Castable 22 H-W Lightweight Castable 22
		H-W Lightweight Castable 20
		H-W Lightweight Castable 10 H-W RC Castable

*These products may also be gunned.

A complete series of gunning, ramming and casting refractories is available from Harbison-Walker to meet every furnace operating condition and temperature requirement. Harbison-Walker engineers will help you select the proper brands to assure best balanced service life. Write us for complete details.

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HARBISON-WALKER REFRACTORIES CO. AND SUBSIDIARIES *World's Most Complete Refractories Service*

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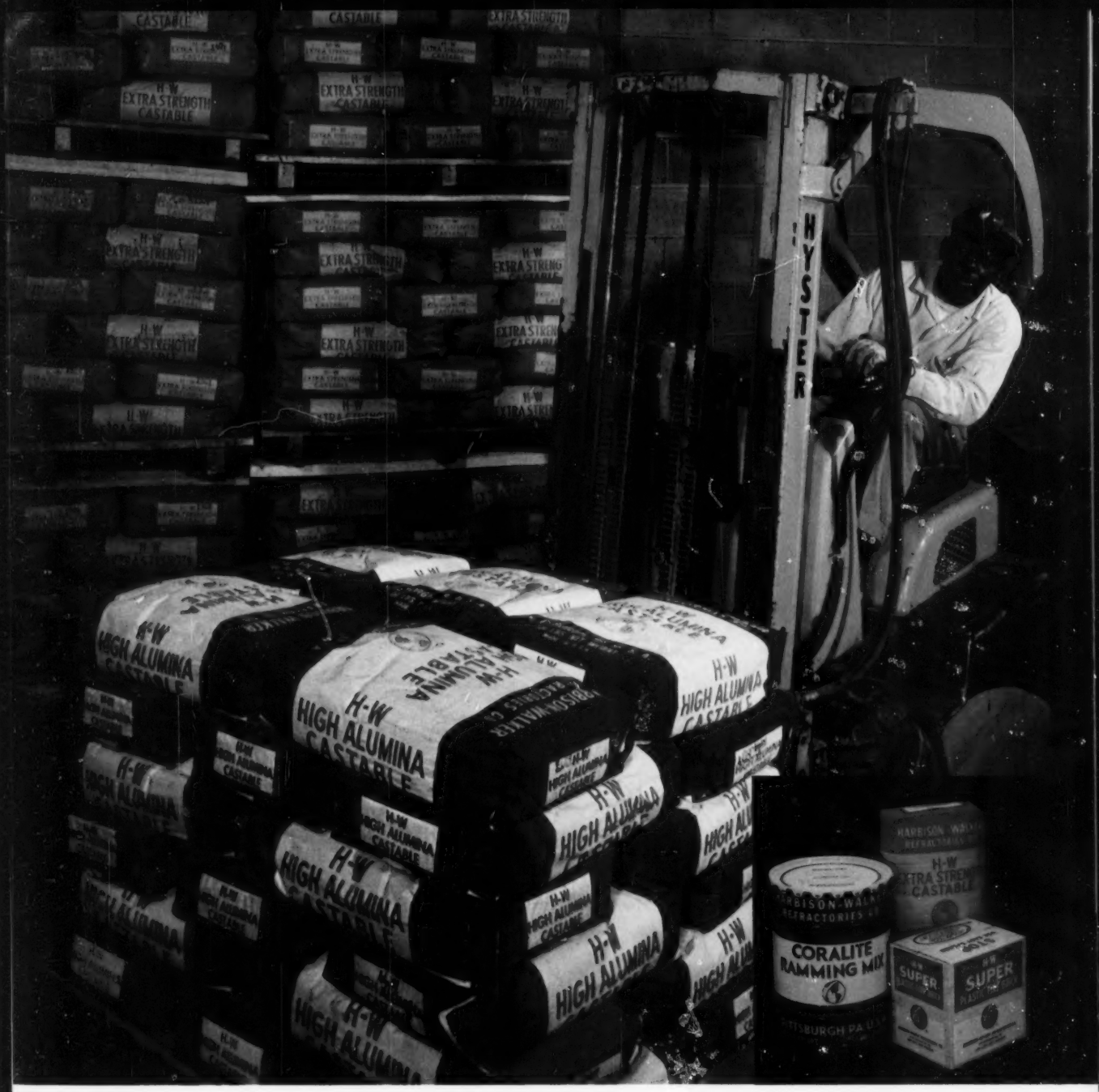

HARBISON-WALKER MONOLITHIC REFRACTORIES

Now packaged for easy handling and time saving on job site

Newly-designed square-end bags, zip-open cartons and sturdy steel drums provide users of Harbison-Walker's monolithic refractories with easy handling, better palletizing and efficient storage advantages. A distinctive color for each brand speeds product identification on the job site.

The bags for packaging castables are made of sturdy, multi-wall, moisture-proof material. Brand names and mixing directions are clearly printed on each bag. The easy-to-handle zip-open cartons contain plastic refractory slabs wrapped in polyethylene moisture-proof material, insuring good shelf life. The results—besides easy and efficient handling—substantial savings of time and labor in installation.

HARBISON-WALKER REFRACTORIES CO.
AND SUBSIDIARIES *World's Most Complete Refractories Service*
GENERAL OFFICES: PITTSBURGH 22, PENNA.

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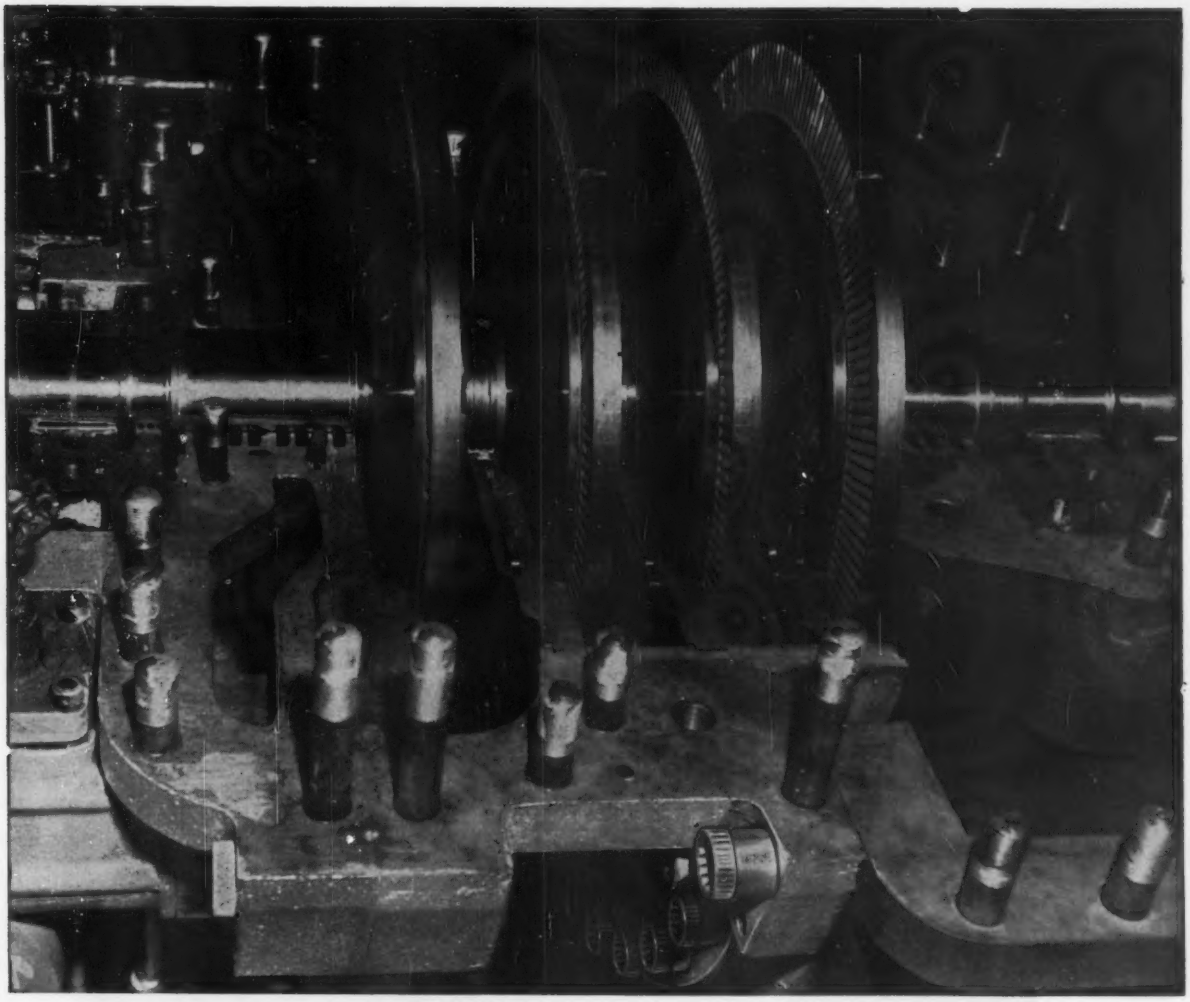

THE INSIDE STORY OF A MURRAY HIGH SPEED COMPRESSOR

DRIVE TURBINE REVEALS THE REASONS FOR MURRAY'S UNIVERSAL ACCEPTANCE

A look at MURRAY'S rugged construction from the inside shows the husky shaft and heavy accurately formed discs with generous sized hubs designed to withstand the axial and radial stresses imposed by this type of service.

Large-dimension disc rims receive the specially contoured stainless steel blades with the Murray integral shroud. This insures smooth steam passages with maximum strength.

Short bearing spans insure smooth operation and eliminate the hazard of operating in critical speeds.

A look at the heavy flanges and husky bolting in the actual unretouched shop photo shown above bears out the extreme ruggedness that typifies every feature of Murray construction.

Our nearest representative will gladly help you solve your high speed compressor drive turbine requirements. Just write to Murray Iron Works Company, Burlington, Iowa, for his name.

Murray
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Builders of Steam Power Equipment for Nearly a Century

For more data on advertised products, use cards, last page.

A DP TRANSMITTER

212T TRANSCOPE® Indicating Flow and DP Transmitter gives you all the features you expect from a truly fine DP Transmitter . . . and the only one that can be calibrated linear with flow as well as differential pressure without changing parts.

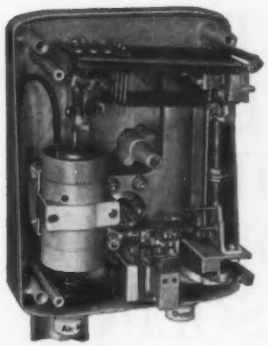
Taylor Instruments

OF MANY USES !

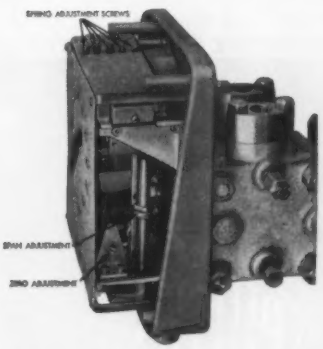
New Taylor 212T Transmitter is first and foremost a superior DP Transmitter . . .

Taylor's 212T TRANSCOPE® Transmitter is an outstanding example of "all this and heaven too". Basically it is a sound DP Transmitter, but when used for flow it can be calibrated to give a linear output without additional parts. It's available in indicating or non-indicating models. And with all its superior features *you pay no premium in price.*

Check the highlights listed here, then call your Taylor Field Engineer for a demonstration and write for **Bulletin 98413.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Ontario.



Open case design provides free access for maintenance.



Diagonally split case gives easy access for all adjustments.

Non-indicating model, showing rear mounting and bottom process connections.

Liquid-filled primary unit means:

Positive overrange protection. Hydraulic overrange protection to full body rating in *either* direction.

Isolation of internal parts. Working parts—except diaphragms themselves—are exposed only to non-corrosive silicone oil.

Built-in damping. Effective pulsation damping occurs at frequencies greater than approximately 2 cycles per second.

Exceptional rangeability.

Normal range span is 20 to 250" water. However, superior design and engineering quality permits over-calibration in either direction with good performance.

Mounting and connection versatility for any installation.

Process connections can be at top, at back or at bottom. ½" NPT fittings set on 2⅛" centers for convenience in piping directly to standard orifice flange taps. Universal mounting bracket can be secured to standard 2" horizontal or vertical pipe, or bolted to flat surface.

Good, clean mechanical design.

Diagonally split case makes all calibration adjustments easily accessible by simply removing cover. Zero adjustments can be made externally. Sturdy, protective case, designed for field locations.

PLUS

Servo power for square root extraction.

Produces an output directly proportional to flow or differential pressure . . . a cost-and time-saving feature when applied to computer control, or ratio and cascade control systems.

Servo power for indication accuracy.

Powerful servo relay drives tape movement to provide indication on a big 11¾" scale. It eliminates the necessity for externally mounted receiver gages.

MEAN ACCURACY FIRST

PUMPS PLAY KEY ROLE IN THIS UNUSUAL SKID MOUNTED GASOLINE PLANT

Peerless pumps circulate, boost, transfer and load finished product at Cheney Gasoline Plant...

When the Cheney Gasoline Plant of Kansas Hydrocarbons went on stream, it marked a new innovation in plant construction. The entire facility, built by Stearns-Roger was constructed and preassembled in their Denver shops. All equipment, except for a few process auxiliaries were skid mounted, then trucked to the job site for final installation.

The plant, built to process propane, butane and RVP gasoline, employs a wide variety of Peerless pumps to keep a smooth, steady process flow. For example, a Type DM pump is in fractionator reflux service. Another Type DM serves as a hot oil pump. There is a two stage Type TPRS pump handling lean oil and propane. The cooling tower has a Peerless Type A pump circulating 1800 gpm for process cooling. And two Peerless Hydro-Line models are handling the product loading function.

Just as they are getting the job done in the Cheney Gasoline Plant, Peerless pumps can perform a key role in your plant or process.

Dependable operation, quality construction, maximum parts interchangeability are but a few of their many features. Get more facts now. Write us today for catalog and name of the Peerless representative in your area.

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HYDRODYNAMICS DIVISION
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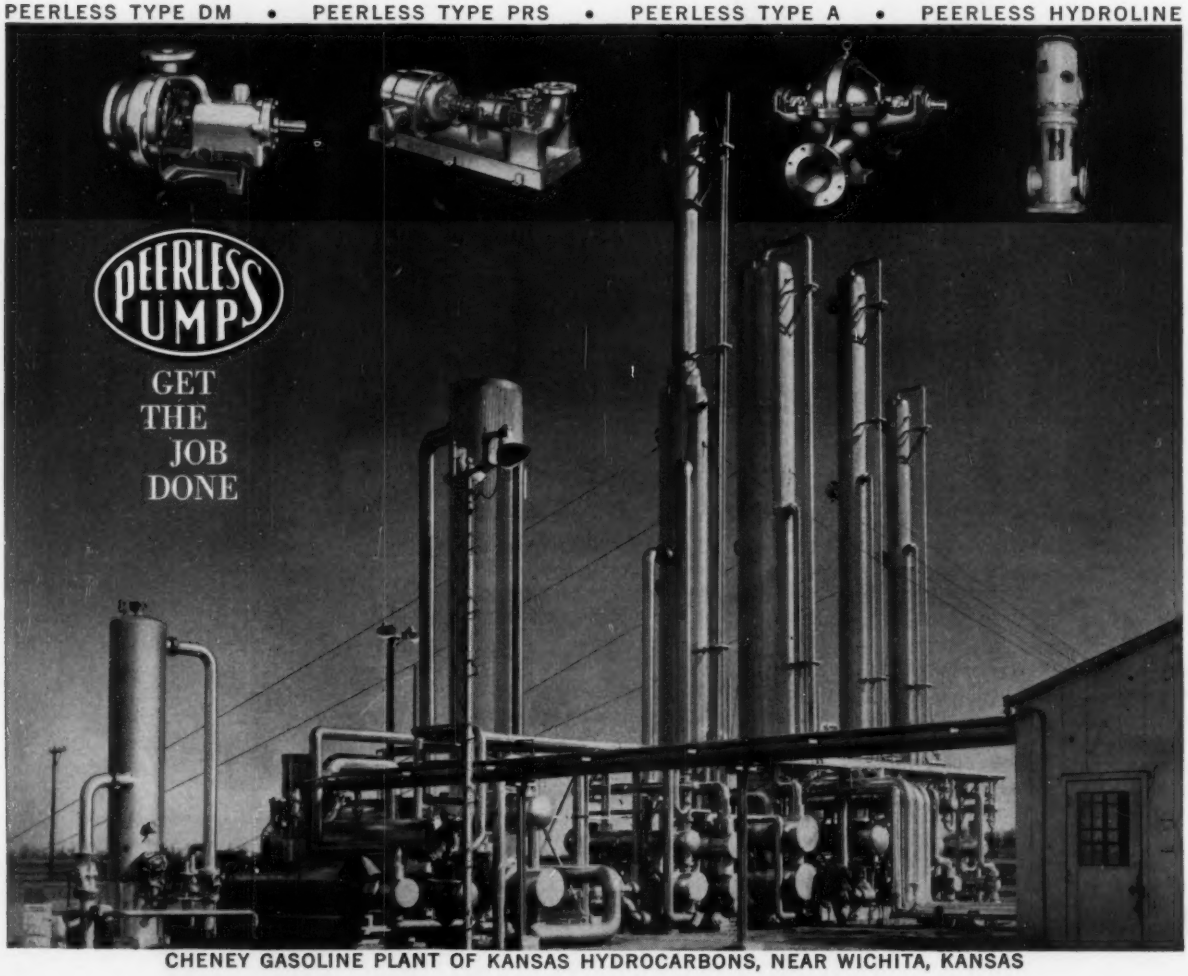
PEERLESS TYPE DM • PEERLESS TYPE PRS • PEERLESS TYPE A • PEERLESS HYDROLINE



CHENEY GASOLINE PLANT OF KANSAS HYDROCARBONS, NEAR WICHITA, KANSAS

sharp

AMERICAN BI-METAL THERMOMETERS make accurate temperature readings sharp and sure at all check points

American Dial Thermometers are also available in mercury, vapor pressure, and gas actuation . . . on-the-spot and distant reading types . . . in sizes, ranges and stem lengths to meet your most exacting requirements.

sensitive

Any way you look at an American Bi-Metal Thermometer, you see exact working temperatures.

The two-level "Maxivision®" dial eliminates parallax effects. Numerals are on the lower level. Graduations are on the outer raised ring dial which presents a sheared edge to the tip of the pointer and in the same plane. To make readability even more accurate, the glass and graduated dial are closely spaced.

American Bi-Metal Thermometers are made of weather-proof stainless steel. All joints are welded to solid unity, then polished smooth so corrosion won't build up and destroy the thermometer's usefulness. And, you don't have to discard this thermometer even if the glass is ever broken. The bayonet lock bezel makes replacement easy.

Learn about the high sustained accuracy and long service life built into American Bi-Metal Thermometers. Phone your nearby industrial supply distributor for help in selecting the right type for each temperature check point in your plant. Or write for Catalog 155.

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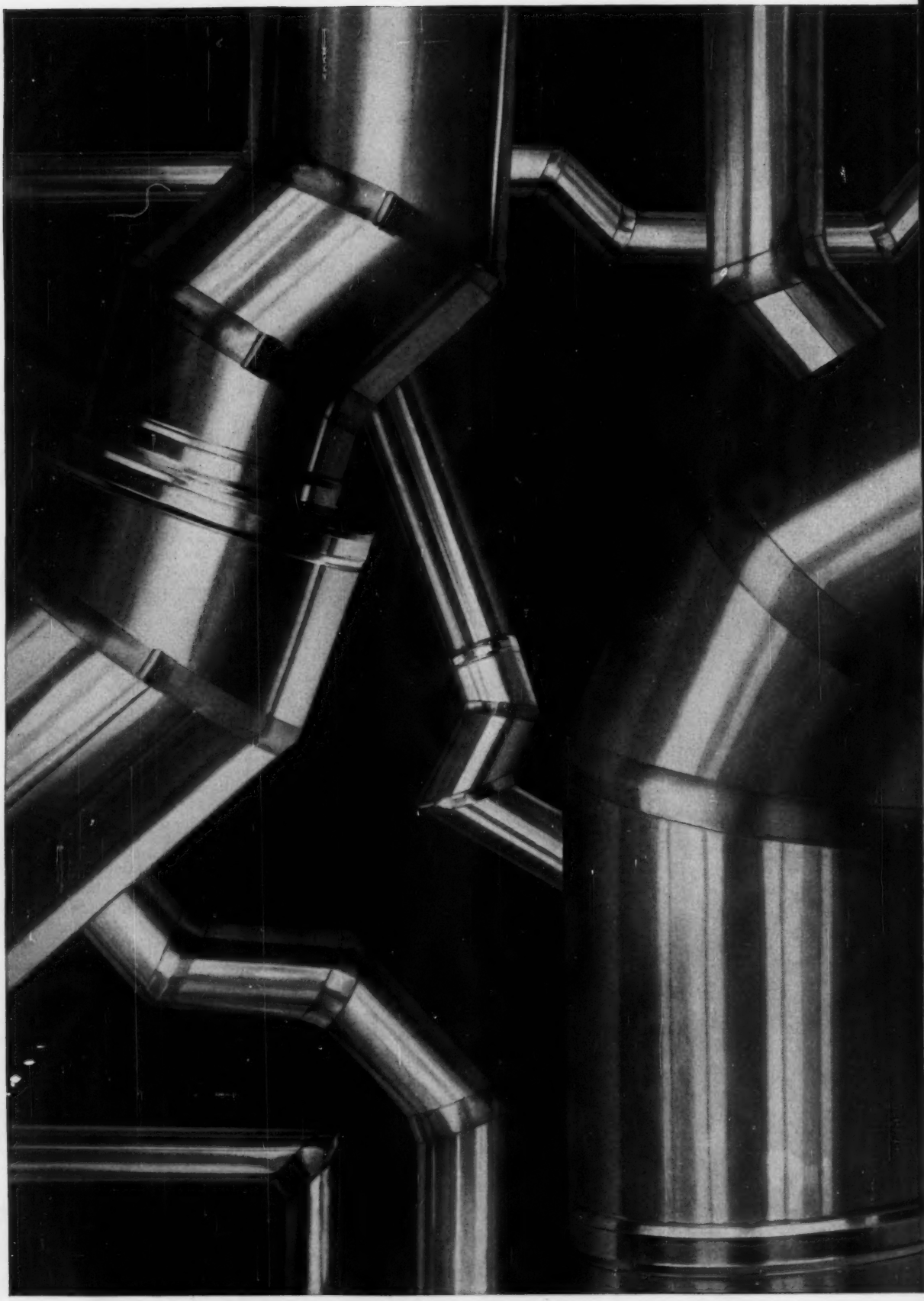


Now! J-M Metal-On covers all the angles

WITH NEW J-M MITER-SEALS, YOU CAN USE METAL-ON TO INSULATE ELBOWS, BENDS, SWEEPS AND TURNS

Now you can protect your *entire* pipe-line system with Johns-Manville Metal-On®...the Thermobestos®, calcium silicate insulation prejacketed with weather-proof aluminum. Yes, even the most complex elbows, bends, sweeps and turns can benefit from the superior insulation of Metal-On.

J-M research has developed Miter-Seal®, a factory-made, preformed aluminum band. It has a clip at one end that can be tightened in a flash with a J-M Banding Wrench. *One* measurement, *one* cut, *one* application, and both insulation and jacket are applied. A quick turn of the Banding Wrench on the Miter-Seal completes the job! (See below.)

For full details, write to J. B. Jobe, Vice President, Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada: Port Credit, Ont. Cable: Johnmanvil.

THE MATERIALS

Miter-Seal

J-M Banding Wrench

THE METHOD

Mitering section of Metal-On. Both jacket and Thermobestos are cut in one step with ordinary carpenter's saw.

Mitered section of Metal-On is placed on 90° fitting.

Miter-Seal sealing compound is placed in mitered joint.

Miter-Seal bands are applied and tightened to finish fitting.

JOHNS-MANVILLE

AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

HIGH CONTENT TEFLON* LATTICE BRAID PACKING...

now at regular packing prices!

Garlock Teflon-Impregnated LATTICE BRAID† Packing is a natural choice for leakproof operation of centrifugal and rotary shafts, valve stems, expansion joints, reciprocating rods, rams, plungers.

An exclusive Garlock manufacturing technique now offers Teflon-Impregnated LATTICE BRAID Packing** for approximately 40% less than ordinary Teflon packing . . . yet this superior new packing contains *more than 30% Teflon by actual weight.* Teflon powder is thoroughly sintered prior to treatment by a unique Garlock process, giving greater stability under temperature changes (−90° to +500°F). Outstanding resistance to glazing. Minimum swell, because Teflon is non-absorbent. Reduced friction and wear, because Teflon is virtually "frictionless." Excellent resistance to chemicals and corrosives.

And LATTICE BRAID construction affords greater strength, longer life, lower maintenance cost. Each strand of treated yarn is interwoven at a 45° angle through the packing body. Completely integrated structure for maximum strength. No single outer braid to wear through. Holds together much longer. Once properly installed, further gland adjustment is usually unnecessary.

Available in two types for efficient, low-cost sealing under all conditions:

GARLOCK 5875 Packing of Teflon-Impregnated WHITE Asbestos for corrosive and strong chemical service (except strong mineral acids and caustics). Withstands neutral and alkaline water, weak acid and caustic solutions. Edible liquids, paper pulp and other products where non-contamination is required. Gasoline, oils—cold and hot (including tar, asphalt, creosote).

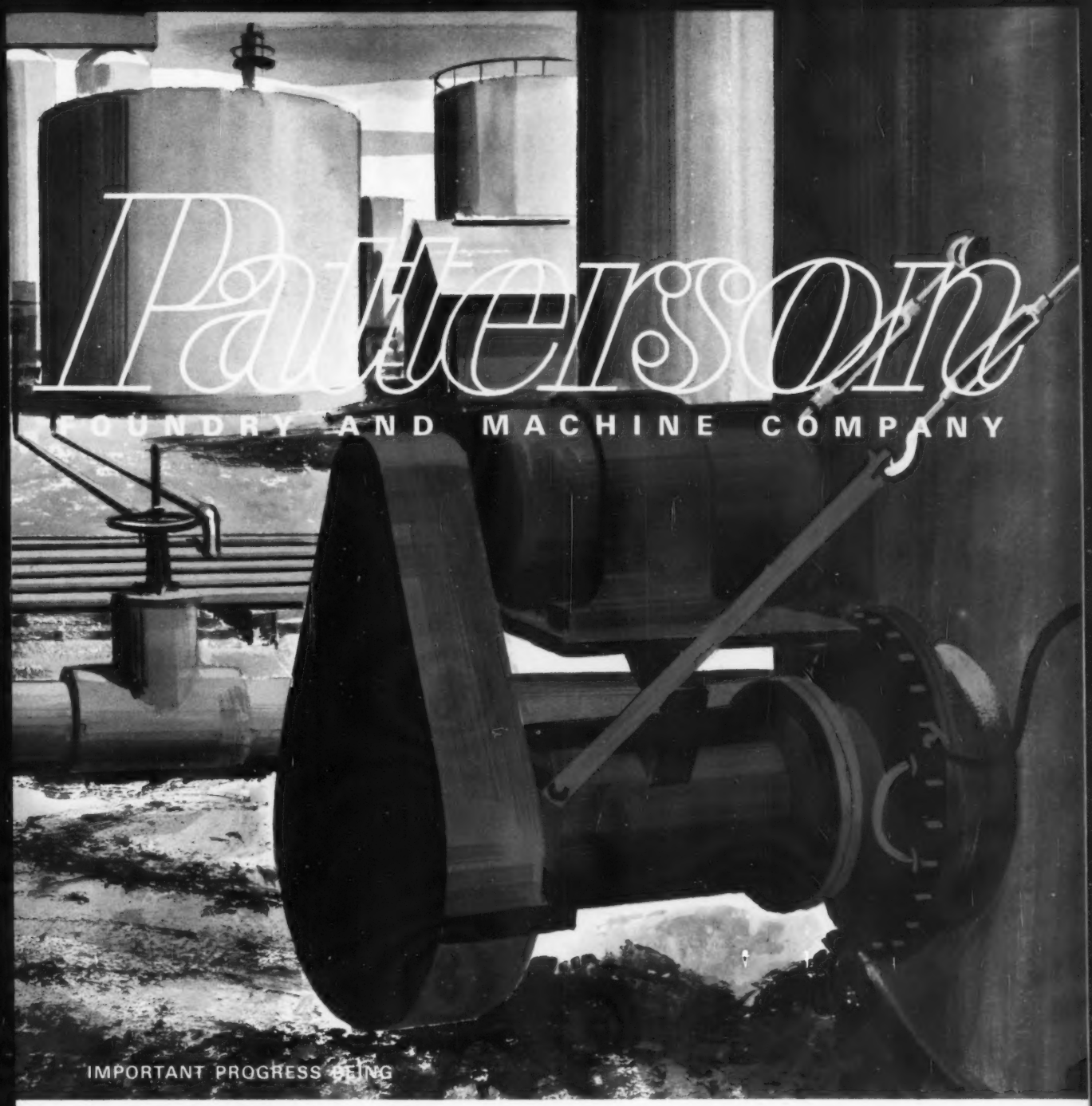
GARLOCK 5881 Packing of Teflon-Impregnated BLUE Asbestos specifically designed for strong acids and caustics. Also resists alcohol, lime solutions, acid sludge, waxes, chlorine, dry solvents. Withstands high pressure steam cleaning. Proved non-nitratable in laboratory test.

Enjoy fast delivery from warehouse stock. Both styles immediately available in sizes from $\frac{1}{4}''$ to $\frac{5}{8}''$ in $\frac{1}{16}''$ increments and $\frac{3}{4}''$ to $1''$ in $\frac{1}{8}''$ increments in spool or reel form. For more information, contact nearest of 26 Garlock sales offices and warehouses throughout the U.S. and Canada. Or, write for Catalog AD-185, Garlock Inc., Palmyra, N.Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd. **Plastics Div.:** United States Gasket Company. **Order from the complete line** of quality Garlock products . . . Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Stock and Parts.

*Du Pont Trademark **Patent Applied For †Registered Trademark



MADE FOR PETROLEUM AGITATION

Patterson, now under a new management team with vital and dynamic new ideas and engineering are advancing on every front! In petroleum agitation devices, Patterson's new equipment promises to be second to none in wanted features, in quality and ability to do the job year after year with little or no maintenance problem. Talk with the man from Patterson about your agitation needs. His new equipment can go a long way to save you money initially and during the years ahead!

TURN THE PAGE

FOR MORE INFORMATION

Patterson Foundry & Machine Company

Gentlemen:

*Please arrange to contact us about a*_____

_____

NAME_____

TITLE_____

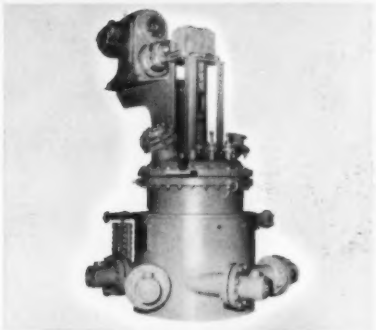
COMPANY_____

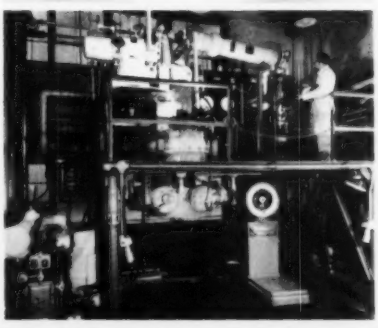
CITY_____ STATE_____

Current Production at Patterson FOUNDRY AND MACHINE COMPANY for the Petroleum Industry

Soap Mixers and Process Kettles

Illustrated is the Patterson Soap Kettle. It is but one of the many different types of kettles and process equipment in which Patterson specializes. Each individual requirement is carefully studied and equipment is engineered to fit your needs. Others are in use as autoclaves, nitrators, sulphonators, digesters, condensers, etc. Regardless of the purpose of your mixing and systems equipment be sure to check the vast numbers of items made for processing industries by Patterson.





The Patterson Grease Kettle

In today's rapidly expanding production systems in both the petroleum and petrochemical fields, Patterson equipment is accepted as standard. The reason, is installations for grease kettles such as the one shown here have operated continuously for more than 20 years without loss of production time. Superb workmanship, highest quality materials, guarantees Patterson reliability. Check your requirements for all types of processing equipment with the man from Patterson!

Pressure Vessels

Available in a wide variety of sizes and jackets equipped with drives, stirrers and valves to fit a vast range of reaction situations, Patterson Pressure Vessels offer the maximum in service and dependability. You may have your choice of lining, controls, etc. Specifications will be carefully evaluated by Patterson engineers and the best and lowest cost installation recommended to fit your needs. Consider Patterson for the finest and most adaptable Pressure Vessel equipment.

Pilot Plant Reactor

These units are extremely adaptable to a wide variety of pilot plant systems. The basic unit can be expanded by additional optional equipment. Illustrated is a unit complete with accessories and controls. Ask your representative for a complete explanation of this and other Patterson equipment.

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No Postage Stamp Necessary If Mailed in the United States

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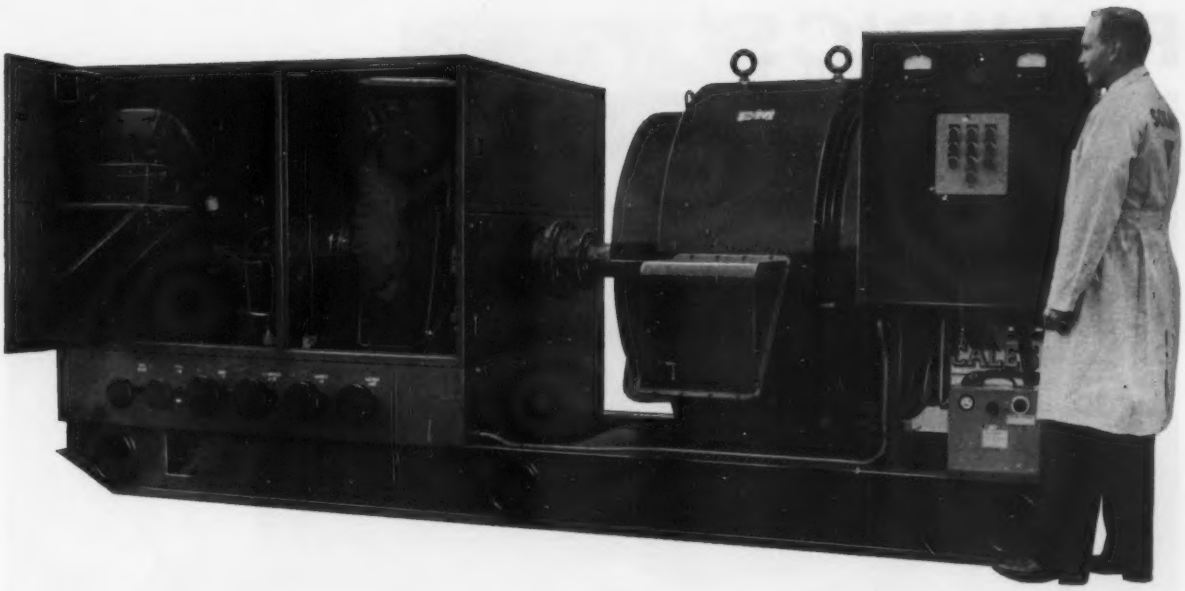
Patterson Foundry & Machine Company

East Liverpool, Ohio

MAIL INQUIRY TODAY

to express our thanks... the first 100 will receive a fine ball point pen with a draftsman point!

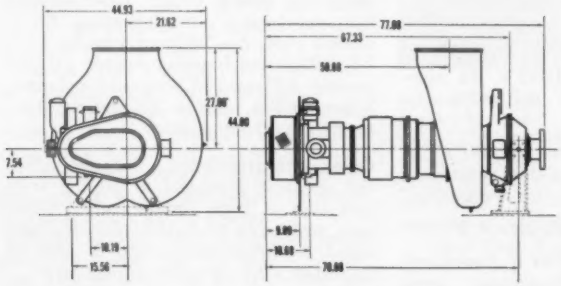
Litho in U.S.A.



800 KW!

Solar industrial gas turbine generator sets ideal for peak loading or constant duty

Versatile, compact industrial generator sets powered by Solar's T-1000 gas turbine engine have a nominal rating of 800 kw. They are ideal for either peak loading or constant duty electrical power applications. Simple design and rugged construction reduces maintenance



to a minimum. Installation is extremely simple. The engine is about 1/10th as heavy as diesel units of similar horsepower and occupies only 51 cu ft. No elaborate foundation or flooring base is required because the gas turbine is practically vibration-free.

Equipped with one of the several control systems available, the engine can be operated remotely and entirely automatically. It starts instantly and operates at full load without warmup, even after long periods of standby service.

Fuel economy of the Solar T-1000 engine is unmatched in its field. The engine runs equally well on a variety of fuels including gasoline, diesel fuel and natural gas. The exhaust may be used in a waste heat boiler or as combustion air in process apparatus or conventional boilers.

Cost of this gas turbine is competitive with diesel engines in many industrial applications. For further information on Solar's turbine-powered generator sets, its complete line of gas turbine engines or industrial compressors, write to Dept. J-144, Solar Aircraft Company, San Diego 12, California.

SOLAR

A subsidiary of International Harvester Company

For more data on advertised products, use cards, last page.

FLUIDICS* AT WORK

Pfaudler factory inspector electric-tests **Nucerite** bayonet heater (6⅝" dia. by 68" long) designed for experimental use in high-temperature sulphuric acid environment.

Progress report:

NUCERITE moves into limited production

Now, there is a practical way to cope with a broad range of corrosives in the 500 to 1500°F temperature range.

It's Pfaudler® Nucerite,* a recently developed family of ceramic-metal composites that resist corrosion at these high temperatures.

Various formulations of Nucerite have undergone field testing on a wide scale since this group of materials was introduced last year. Results indicate many practical applications for Nucerite in the 500 to 1500°F range. Very few materials available up till now would withstand these temperatures, and even then only under extremely limited conditions.

Limited production. Where field tests or lab data substantiate the serviceability of Nucerite in a given application, Pfaudler now accepts orders for production equipment of simple shape, rounded corners, and uniform cross section.

Successful tests. You can get some idea of the range of applications for Nucerite from this representative list of successful field tests:

1. Metal halides at 1292°F (a specialty alloy failed in this service in 2 to 3 weeks).
2. Cl_2 and CCl_4 mixture at 600°F (a quarter-inch stainless steel piece corrodes through in a matter of minutes).
3. Refractory metal chlorides at 485°F.
4. Coal tar pitch at 750°F (solid ceramic materials previously used failed here due to thermal shock).
5. Aqua regia plus heavy abrasive at 225°F (tantalum is the only metal which could withstand this condition).
6. HCl plus solids (100 f.p.s.) at 1112°F.

Nucerite equipment. Among the equipment for which orders have already been received, are the following: 6"-diameter pipe, 2½"-diameter boiler tube, 6⅝"-diameter bayonet heater (shown above), 12"- and 18"-diameter columns, finger baffles, and a 300-gallon "RA" series closed-top reactor.

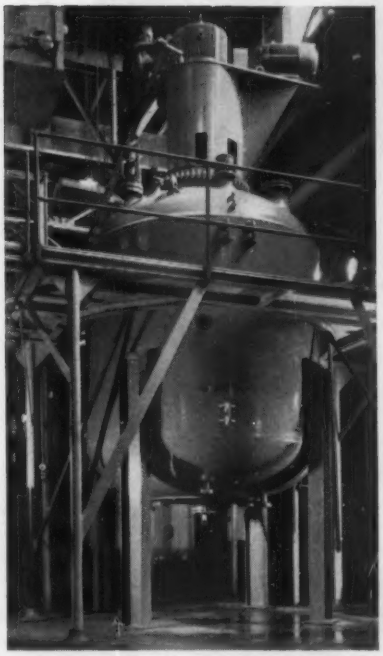
Other characteristics. Nucerite offers the greatest potential in coping with corrosion at high temperatures. However, resistance to impact, abrasion, and rapid temperature change is also of importance for specific applications.

Data available may indicate which formulation of Nucerite can best solve your particular problem. If not, we invite your participation in a field evaluation program.

For more information, write to the address shown on the facing page.

*Patent applied for

Is this tank BIG enough?



Since "big" is a relative term, let's get down to specifics. The reactor pictured here stands 26' 3" to top of drive, measures 120" I.D. by 98" straight-side for a capacity of 6000 gallons. It is made of Pfaudler® Glasteel—glass inside for corrosion resistance, steel outside for working strength.

The agitator drive is also Pfaudler-made. It's our basic TW type, rated here at 75 HP. Actually, this drive can handle up to 200 HP.

As vessels go, this one is *medium-sized*. For example, 35,000-gallon Glasteel storage tanks are a common sight on our production lines. Reaction vessels usually run a little smaller. Like the 17,000-gallon one we recently shipped to a PVC plant.

Which brings us to another aspect of Glasteel—its eminent suitability for polymer production. For many reasons. First, Glasteel gives you a product-contact surface that is *inert*. It will not contaminate or discolor materials you use in making synthetic resins. Nor will it act as a catalyst to set off undesired side reactions.

And Glasteel is *smooth*. Even sticky substances do not adhere readily to its fire-polished surface. What little does is easily washed away. Thus, you can expect high production rates with minimum down time.

Finally, Glasteel is economical, not only in terms of long life but also from the standpoint of initial cost. It is significantly less costly than the specialty alloys you would consider where product purity is vital.

Offer: When it comes to meeting your needs for really big process equipment, we have the skills, experience and facilities. Recent factory expansion makes the big ones a challenge we welcome. Inquiries invited. Write to the address indicated.

How tantalum helped Hoffmann-LaRoche scale up production

Here's the problem: You're making a relatively new drug, using a process that requires holding a mixture of phosphoric and hydrochloric acids at 385° F for several days.

You've been turning it out on a pilot-plant basis, using flasks. Market conditions require that you get into full-scale production. How?

The nature of the corrosive reaction narrows your choice to three materials: tantalum, gold, and platinum.

That's the situation Hoffmann-LaRoche Inc., Nutley, New Jersey, was up against recently. The practical answer: a 275-gallon, tantalum-lined reactor made by Pfaudler.

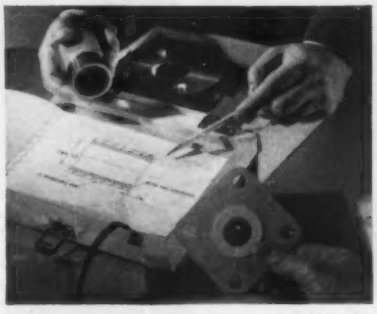
We say practical because tantalum is essentially inert and does not combine with the process ingredients to cause contamination. Practical because tantalum resists most acids, even at elevated temperatures. Practical because a .020" tantalum liner in a 5/16" carbon steel shell is reasonably priced.

And, finally, practical because Pfaudler brings to the fabrication of such equipment a wealth of experience and capability. We can and do work with tantalum, titanium and zirconium, so that you can look to these metals to solve your corrosion problems.

More facts? Bulletin 978 summarizes our activities in the "refractory" metals. We'd be happy to send you a copy.

Address all inquiries to our Pfaudler Division, Dept. PR-91, Rochester 3, N. Y. In Canada, contact Pfaudler Permutit Canada Ltd., Toronto.

Special gasket assures precise alignment for F-C Glasteel pipe*



This is the high-integrity glass-lined pipe that you can cut, thread, fire-polish and install right in the field. And to make sure that gaskets seat properly when you join sections, we've taken special precautions to assure precise alignment of the pipe axes.

Here's how: Flange bolt holes have been made *only* 1/16" oversize, rather than the conventional 1/8" oversize. In addition, the bolt holes in the gasket itself have also been made *undersize*. The gasket is thereby centered with the axial center line of the pipe and limits non-parallelism of the flanges.

Both the pipe and the gasket joints have been extensively tested — in the field and in our Test Center. For example, intermittent tests over a seven-month period were made with the following acids: 10% sulphuric, 10% nitric, and 20% hydrochloric. Pressures ranged from 50 to 125 psi, with temperatures from 160 to 300° F. *There were no failures of either the glass lining or the gaskets.* Similar results have been reported for actual installations, including one of 850 feet, in operation since early summer a year ago.

You'll find F-C pipe well suited to handling many "problem" liquids—corrosive, abrasive, and ultra-pure. It comes in 1½-, 2- and 3-inch diameters, with quick delivery on any length up to 10 feet. Write for Bulletin 987.

*Patent applied for

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

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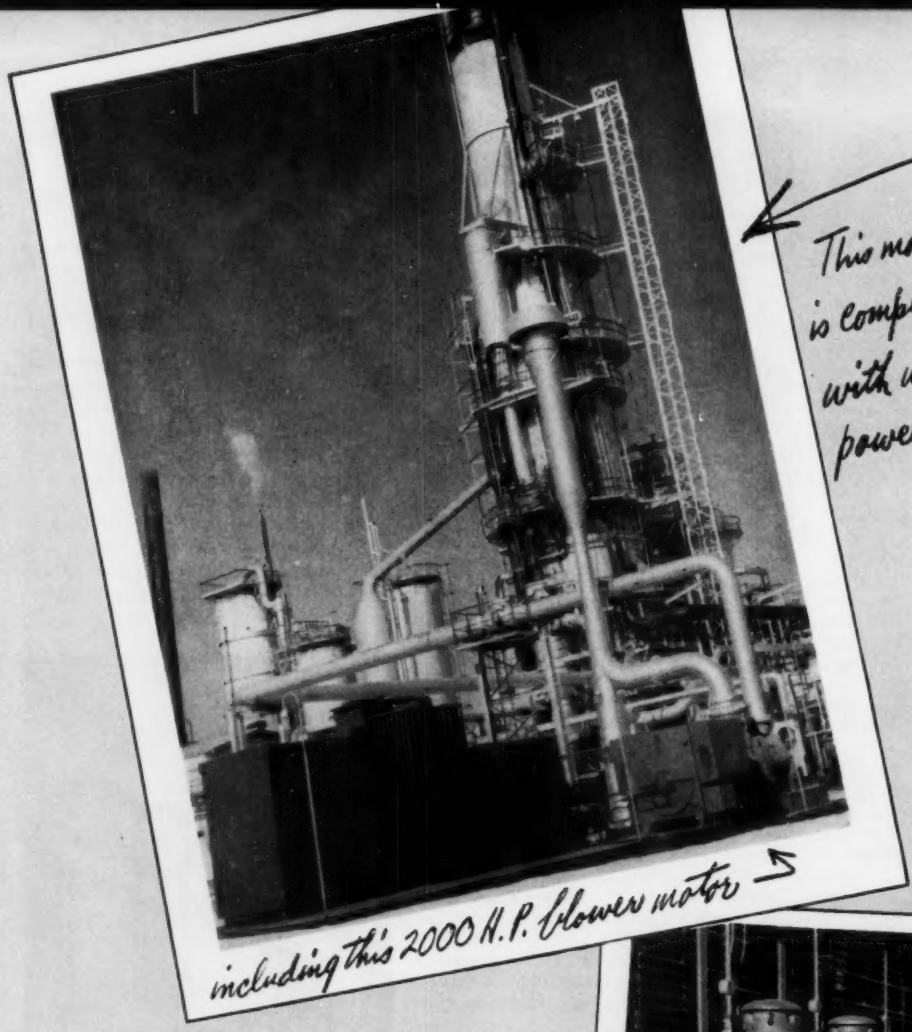
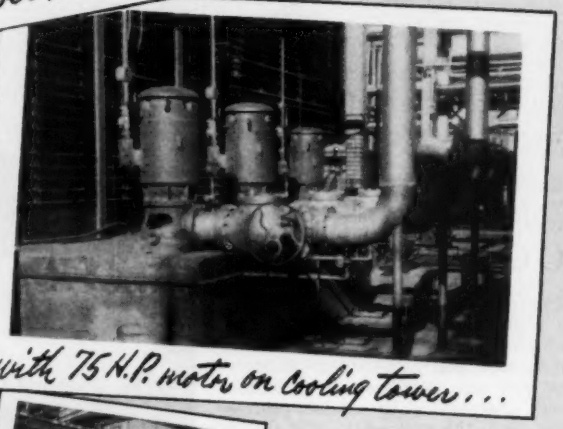
For more data on advertised products, use cards, last page.

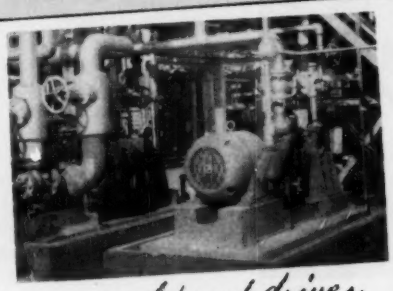


This modern refinery is completely electrified with utility electric power throughout...

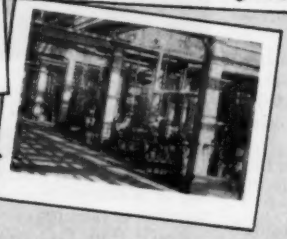
including this 2000 H.P. blower motor



with 75 H.P. motor on cooling tower...



...and pump drives



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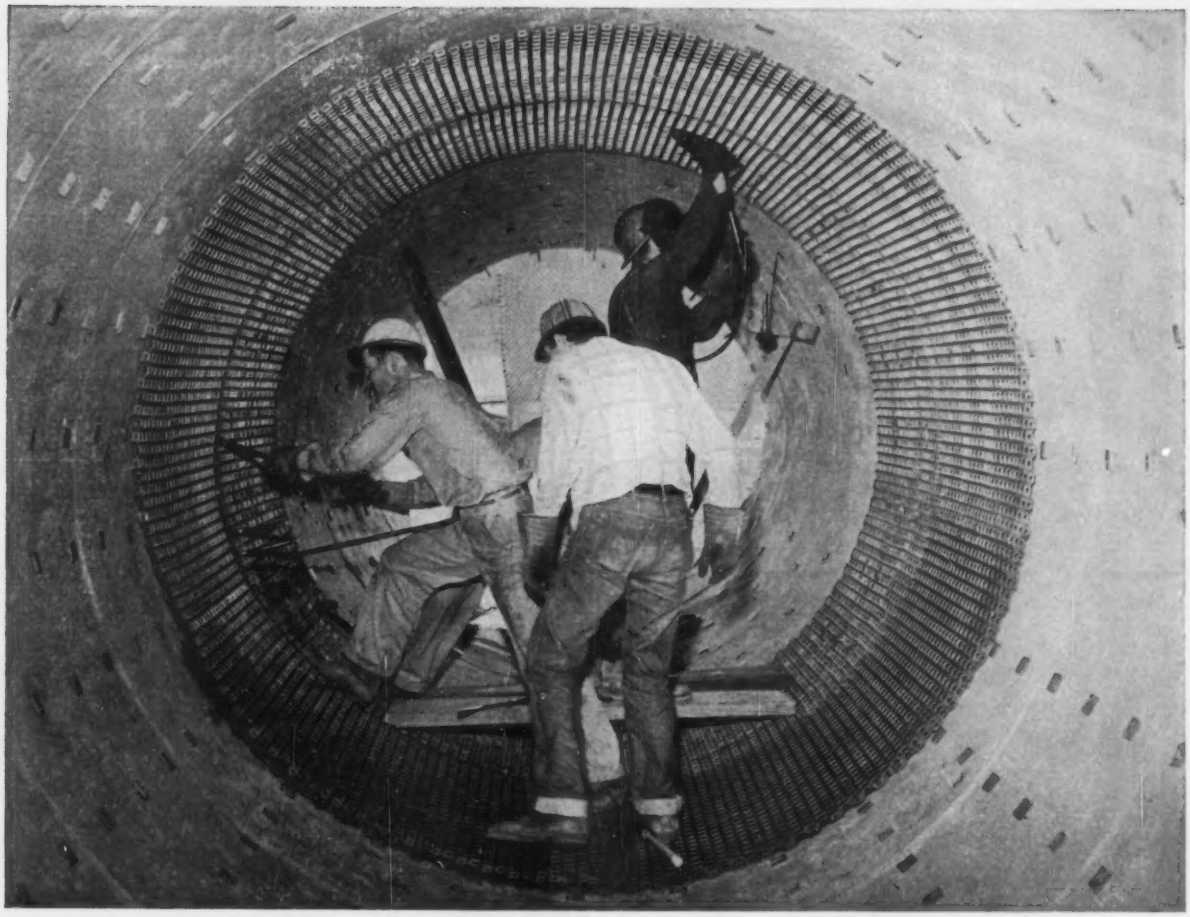
Refractory insulating concrete protects catalyst lines against erosion



Gunite Contractor: J. A. McCollum, Inc., Marlton, N. J. Castables: Kaiser Refractories & Chemicals Div.

In this catalyst line at a large Gulf Coast refinery, steel mesh is being welded into place over a 3-inch lining of refractory insulating concrete made with LUMNITE calcium-aluminate cement. Over the mesh, a 1-inch thickness of high-strength castable will be gunited, providing a 2-component refractory concrete lining that will resist severe erosion and abrasion caused by catalyst fines. Monolithic refractory concrete linings eliminate troublesome mortar joints. They are easily placed, conforming to any contour. Castables are recommended because they are simply mixed with water and placed – concrete reaches service strength in 24 hours. Castables containing LUMNITE cement are available from leading manufacturers of refractories for a variety of applications in refinery equipment. For information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

"USS," "Atlas" and "Lumnite" are registered trademarks.

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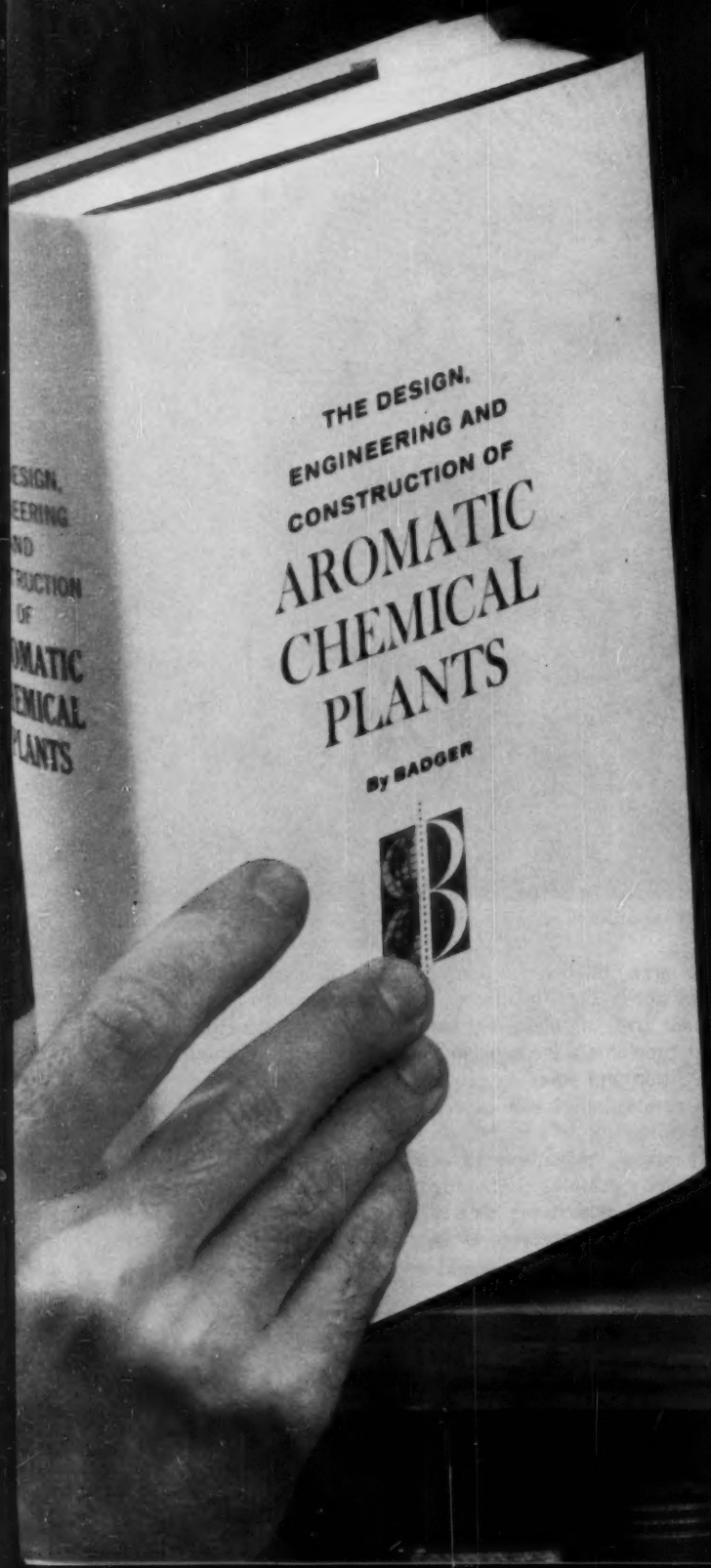

ONLY BADGER COULD WRITE THE AUTHORITATIVE TEXT

Since 1952 Badger has designed, engineered and constructed thirty-eight plants for the production of aromatic chemicals. Their total worth exceeds $70 million; plants range in value from $.3 million to $10 million.

These impressive figures tell only some of the reasons why Badger could "write the book" on aromatics — whether it involves the production of crude products . . . their purification . . . or their conversion into other organic products. Without exception the plants demonstrate the exceptional creativity which is an important part of the stock in trade at Badger. In fact, many of them owe their existence to totally new — in some cases revolutionary — design and engineering ideas. Others, based on more classical engineering concepts, could have been routine plants producing routine products at routine costs. That they are not is again due to the full measure of creativity Badger has brought to their detailed engineering and construction.

When you are considering new facilities for the production of any aromatic, talk first to the people who have made a habit of success in the field. Ask the Badger man for the full story — write, wire or phone today.

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The Mail Box . . .

Questions Validity of Complaceny Charge

Please allow me to answer Mr. Harry L. Harrity's letter in the August issue regarding portions of three articles in the June issue, including mine on "How to Retire." He says these "typify the complacent attitudes and wishful or unscientific thinking of most Americans."

(1) I do not see any basis for interpreting Donald Frendzel's statements into Mr. Harrity's statement ". . . that trade with the Russian slave-drivers will benefit their slaves and lead to peaceful coexistence." It seems to me that Mr. Frendzel has attempted to give both sides of the Russian threat with emphasis on the bleak side of it, i.e., five items that are bleak and four that might be favorable to the West.

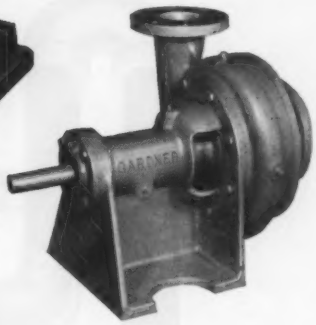
(2) In Mr. Harrity's statement of part of a sentence from the Look Box on American Optimism, "American foresight will be better than that of others," he left out the word "likely" and changed part of the rest of the sentence. It read, "None the less, American foresight **likely** will be better than that found in other parts of the world." The author, in the 1959-60 edition of "The American Scholar," in my opinion, expressed his opinion and good reasons for that opinion. It had nothing to do with complacency or wishful thinking.

(3) Mr. Harrity's statement, "Inflation of 2-3 percent per year will continue ad infinitum" is a perversion of what was written in "How to Retire." The actual statement was, "In the past 20 years the purchasing value of a dollar has shrunk about 52 percent, some 20 percent of this being in the past ten years. While this rate of inflation has slowed down to between 2 and 3 percent per year, there is **little** likelihood that it will cease." The paragraph is a warning to the reader that what has happened for the past 20 years **may** continue and points out a hedge against inflation which experienced investors are using. I fail to see how it could be interpreted as complacency, wishful or unscientific thinking. It would be just as reasonable to interpret a statement that a writer might make that juvenile delinquency is on the increase in the U.S.A. to mean that the author approved of it or was complacent. The purpose of my article was to help individuals with their problem of preparing to retire. It had no political implications.

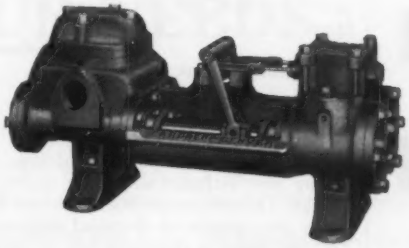
Many people still believe in the classical economics taught in my youth, which would still apply in a perfectly free enterprise economy, but no such economy exists. About 13 years ago, the famous economist of Massachusetts Institute of Technology, Dr. Paul A. Samuelson, included in his book a chapter on how to make a communistic society work. To do this he specified rewards for above-normal productivity. Judging from the Russian's practice of providing incentives for

Quality pumps with rugged reserve for refinery service

Gardner-Denver BH—four sizes. Provide range from 55 to 550 gpm. Designed for high-speed, high-head operation.

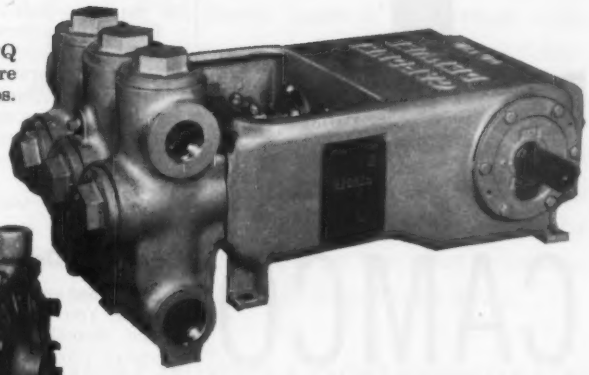


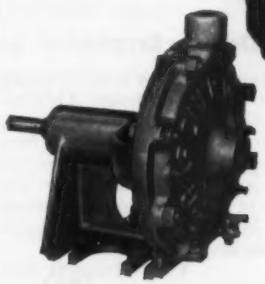
Gardner-Denver BL—five sizes. Provide range from 100 to 1600 gpm. Highly efficient in taking variations in head or volume.



Gardner-Denver duplex reciprocating pumps for operation on steam, air or gas. Eight sizes produce from 9 to 294 gpm.

Gardner-Denver PQ and PS high-pressure triplex plunger pumps. PQ size, 2½x2 . . . PS size, 2¾x2½.





Gardner-Denver CAY 1" reversible circulating pump operates efficiently in either direction. Handles up to 65 gpm.

All Gardner-Denver pumps are engineered with rugged reserve for trouble-free operation and long-lasting duty. Your Gardner-Denver pump specialist can help select the best pump for your requirement. Call him soon, or write for information.

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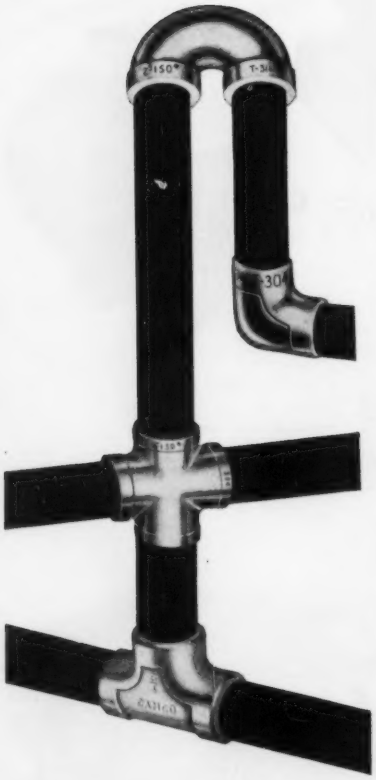

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VSMF

The Mail Box...

superior work, they must have read this book.

When Hitler moved into the Ruhr which was interpreted by many as threatening war, most of the leading commentators, including Dorothy Thompson, maintained that there was no danger of war for Hitler could not conduct a war without money and he had no gold. This shows how we must beware of stereotyped thinking about everything including political economy. Those who are sure they know are unable to learn new things.

No doubt our country and our way of life are in great danger and each of us should be alert in every possible way to help avert such a catastrophe. In closing I would like to suggest that one of the ways each of us can best contribute to averting a communistic takeover is to build a fallout shelter or if living in a critical area, a bomb-resistant shelter, for the less vulnerable we are the less likely the communists will ever use nuclear bombs. Also, we may thereby save the lives of ourselves and our families.

Forrest E. Gilmore
Independence, Kas.

Good Indexing Job

I have been reviewing, in detail, indexing now included with your technical articles. Let me congratulate you on this major new service to chemical engineers. You are doing a thorough job of listing all the key words in your articles.

If more publishers could be encouraged to improve their services along these lines, a major step forward would be made in reducing the technical information problem by providing the access to information by the generating source.

Congratulations on a good job.

B. E. Holm
Wilmington, Delaware

Reboiler Design Errata

Below are errata for my reboiler paper ("What You Need to Design Thermosiphon Reboiler, PETROLEUM REFINER, February 1960). There are quite a few, I'm sorry to say. However, most are inocuous and are just included for the record. Some of them I discovered; others were sent in by various readers. I suggest you arrange to have them published.

James R. Fair
St. Louis, Missouri

P. 107—(Equation 2.) Denominator should be $r_p' + r_h'$.

P. 108—(Equation 5.) Delete ρ_L from numerator.

P. 110—(Equation 14.) ΔP should be negative.

P. 110—Second paragraph in Friction Loss section:
(a) Reference should be to Figure 1 instead of Figure 2.
(b) In Equation 16, dL instead of dD.
(c) Between Equations 16 and 17, change phrase "If the material were all liquid, . . ." to "Considering the liquid portion, . . ."

P. 110—(Equation 18.) Denominator on right should read

$$4f_L V_L (1 - x) dL.$$

P. 110—Equations 20 and 21 should show negative terms on right.

P. 110—(Equation 23) applies strictly to the case where liquid level is even with top tube sheet.

P. 111—(Equation 25.) Term $\Delta p/\Delta L$ should be negative.

P. 112—(Equation 30.) Term on right should be k_L/D_t instead of K_L/D_L.

P. 121—Paragraph immediately before section on Heat Transfer Rate. Multiplying term 0.60 should be deleted.

P. 121—Table 7. In column 7, the value of $\bar{\alpha}$ should be 0.70 instead of 0.070.

P. 122—Example 2, Preliminary Design: The tube number is 96, not 218.

P. 122—Example 2, Circulation Rate: The inlet line is 4-inch pipe. The value of $\Delta t/\Delta L$, for $t_W - t_L = 30°$ F, is 2.3° F/ft. Substitution in (Equation 27) should be:

$$\frac{p_B - p}{p_B - p_A} = \frac{3.6}{3.6 + 2.3/0.31} = 0.33$$

Substitution of corrected values in (Equation 24) gives

$$W_T = \left(\frac{8260}{1.87 + 7.12 + 1.68 + 1.04}\right)^{1/2}$$

$$= 26.5 \text{ lbs/sec}$$

P. 122—Example 2, Heat Transfer Rate:

$$\bar{h}_p = \frac{2.6\,(160) + 5.4\,(530)}{8.0}$$

$$= 410 \text{ Btu/(hr)(ft}^2\text{)(°F)}$$

The calculated U = 300 checks exactly the assumed value.

Errata

In the article "Design Tips for Refinery Tank Farms" which I wrote and which was published in the July 1961 issue of HYDROCARBON PROCESSING-PETROLEUM REFINER there is an error in Figure 2. The ordinate figures which show installed cost, $/bbl. should range from $1.-$6., rather than from $10.-$60. as shown. In other words there should be a decimal point after the first digit in each of the numbers.

A. H. Younger
Taylor, British Columbia

Wanted:

YOUR Ideas . . .

The Editors invite letters from readers discussing timely topics pertinent to the HPI

PETROLEUM REFINER

PROCESS 1961 DEVELOPMENTS

FROM KELLOGG . . .

PROCESS PLANTS TAILORED TO MEET YOUR NEEDS

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Successful plant investments result from the Kellogg approach. This approach is based upon utilization of advanced engineering techniques, coordination of services, full cooperation with clients' staffs, and a fixed price contract philosophy which permits the client to purchase a ready-for-operation plant for a substantially predetermined price. Kellogg can also work with clients on whatever basis is conversant with project requirements, such as in the development or engineering of new processes.

If you are contemplating investment in new process plant facilities, you are cordially invited to discuss your needs with The M. W. Kellogg Company. You, too, may well find that the Kellogg approach provides the most economic route to achieving your investment goals.

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YARWAY news briefs

from **Yarnall-Waring Company,** *Philadelphia 18, Pa.*

BRANCH OFFICES IN 19 UNITED STATES CITIES • SALES REPRESENTATIVES THROUGHOUT THE WORLD
STEAM TRAPS STOCKED AND SOLD BY 270 LOCAL INDUSTRIAL DISTRIBUTORS

DON'T WAIT TILL SNOW FLIES TO PROTECT OUTDOOR STEAM LINES FROM FREEZE-UPS

INSTALL NON-FREEZING YARWAY IMPULSE STEAM TRAPS NOW

Remember last winter?

Will you ever forget those lost production hours and the costly maintenance time resulting from frozen steam lines? Why let it happen again?

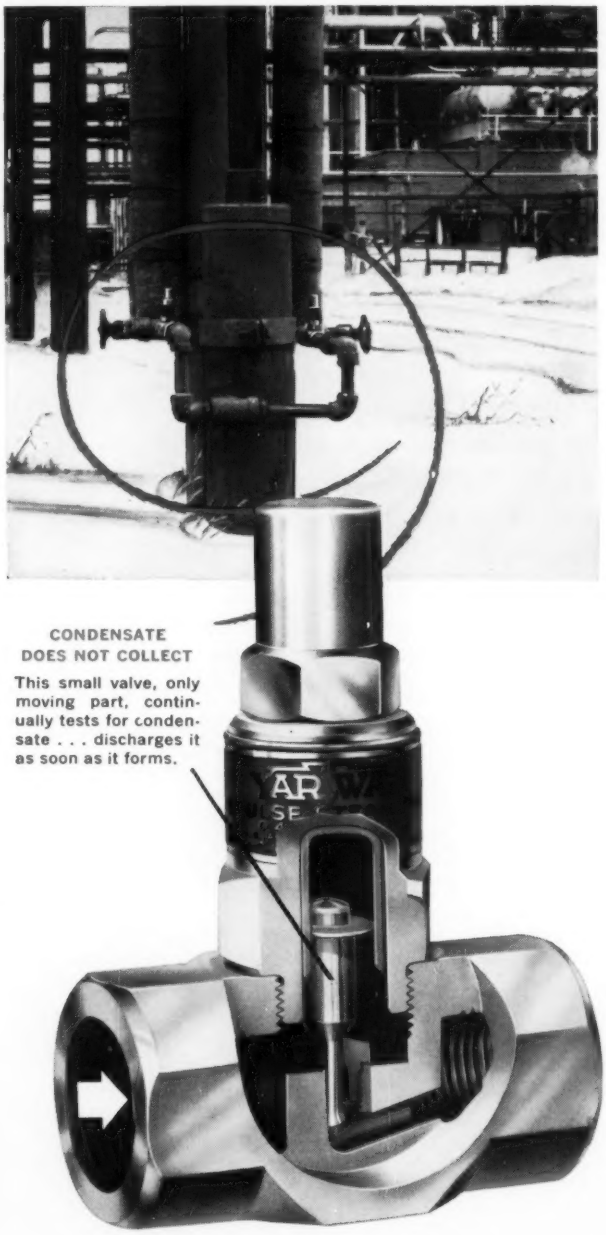
Steam lines and exposed process equipment that you equip *now* with Yarway Impulse Steam Traps—will be free from freeze-ups and ready for peak production later, when temperatures plummet and the "big freeze" sets in.

In the Yarway Impulse Trap there's nothing to freeze. No condensate collects. The only moving part (a small piston-like valve) continually tests for condensate and discharges it as soon as it forms. Result—continual operation of equipment at high, even temperatures.

Consider, also, these other Yarway Impulse features:

- QUICK HEAT-UP
- LOW MAINTENANCE
- STAINLESS STEEL CONSTRUCTION
- SMALL SIZE—LIGHT WEIGHT
- GOOD FOR ALL PRESSURES
- COMPLETE LINE FOR WIDE APPLICATION COVERAGE

Check *your* trapping needs *now*. Yarway traps are stocked and sold by 270 local Industrial Distributors. Write for Bulletin T-1743.



CONDENSATE DOES NOT COLLECT

This small valve, only moving part, continually tests for condensate . . . discharges it as soon as it forms.

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AVERAGE CONDENSATE LOADS	EXTRA HEAVY CONDENSATE LOADS	LIGHT TO MODERATE CONDENSATE LOADS	
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A SPECIAL REPORT

LATEST TRENDS IN REFINING SCHEMES

A source of cheap hydrogen is being sought earnestly by the petroleum refiner. Previously regarded as an inferior component of fuel gas, hydrogen now figures prominently in crude oil processing. In fact latest major advances in refining technology concern catalytic processes which need a hydrogen atmosphere.

Want to Know The Cost of Making Hydrogen?
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So far, the steam-methane reforming route to hydrogen manufacture is the one most used. Another method, partial oxidation, is also becoming very popular—especially in areas where natural gas is expensive or limited.

Announcement and commercialization of modern hydrocracking processes add to the interest in hydrogen. Hydrocracking offers flexibility in product distribution and improved quality for the distillate products it yields.

Condensate Can Be Hydrocracked, Too
Page 167

Research on hydrocracking continues at a fever pitch. The literature is growing with reports on how the process can handle a variety of feedstocks. When combined with reforming, hydrocracking even gives the natural gasoline processor a way to upgrade condensate into a premium grade gasoline.

Isomerize Pentane With This New Reactor System
Page 171

Another process requiring hydrogen is isomerization. Practiced on a limited scale for the production of iso-butane, the process can also isomerize heavier materials. Then it yields products having good gasoline blending properties—both from

an octane and a volatility standpoint. Recent developments in this processing technique are viewed with interest.

New Hydrotreating Process Now in Commercial Operation
Page 175

Nevertheless, hydrogen's main use in connection with fuels production, is the treatment of feedstocks and products. In the U.S., hydrogen treating is growing so that it now is equivalent to 21 percent of the crude handling capacity. In fact, since early last year, hydrogen treating outstripped the other rapidly growing process—catalytic reforming.

Big Revamp and New Units Yield a Modern Refinery
Page 179

But oversupply of petroleum products continues to plague the hydrocarbon processing industry. As with most situations where the supply exceeds the demand, the profit margin is tightening. And what the refiner is doing in the face of this condition is reflected in the technical articles in this special Process Development report.

British Petroleum Puts New Refinery In Canada
Page 182

The impact of oversupply is much less noticeable on new refinery construction outside the U.S. than within. New facilities to handle additional crude are still being installed at a phenominal rate. Each year the refiner outside the U.S. adds enough new processing to up his throughput by over one million bpd. By comparison, expansion within the U.S. is less than one tenth this amount.

What Brazil Added To Bahia Refinery
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On the other hand, predictions for future oil requirements remain encouraging. The present low per capita consumption of energy for many countries offers petroleum fuels an excellent opportunity for growth.

Route to Waxes And Lubes Modernized At DX's Refinery
Page 189

It will be one or two more years, however, before the U.S. refiner will have an incentive to expand his crude handling capacity. Thus his activities are directed toward lowering crude oil prices, reorganizing to join marketing set-ups, acquiring petrochemical processes, and tightening operations within his refinery processing scheme.

. . . Plus new ideas for Process Design
Page 195

But modernization does not stop with processes. Individual unit operations are now eyed with more care. This issue contains an added section including recent developments in process design. Although there is no attempt to give a summary of latest advances in design, you will find the ones discussed here are mighty helpful.

Harold Hoffman

PROCESS AND CONSTRUCTION EDITOR

Want to Know the Cost of Making Hydrogen?

Here is a new look at the economics of making hydrogen. Now you can make a closer examination of two of the processes for manufacturing hydrogen—steam reforming and partial oxidation

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Representative costs for two hydrogen production schemes are discussed here. In the size range of 5 to 15 million standard cubic feet per day the cost of hydrogen is from 51.0 to 38.0 cents per thousand standard cubic feet for steam reforming at 125 psig (assuming 35 cents per million Btu for fuel). For the partial oxidation scheme the cost figures are 68.8 to 49.6 cents per thousand standard cubic feet (assuming $2.50 per barrel of residual fuel). These cost data are summarized in Figure 1.

INTEREST IN HYDROGEN GROWS

Throughout the refining industry interest in hydrogen production is currently at a fever pitch. Announcement and commercialization of modern hydrocracking processes such as California Standard's Isocracking, Universal Oil's Lomax, Union's Unicracking and many hydrotreating processes are reasons for this interest.

For the first time in his existence the oil refiner is considering the conservation of gaseous hydrogen, long regarded as a somewhat inferior component of the fuel gas

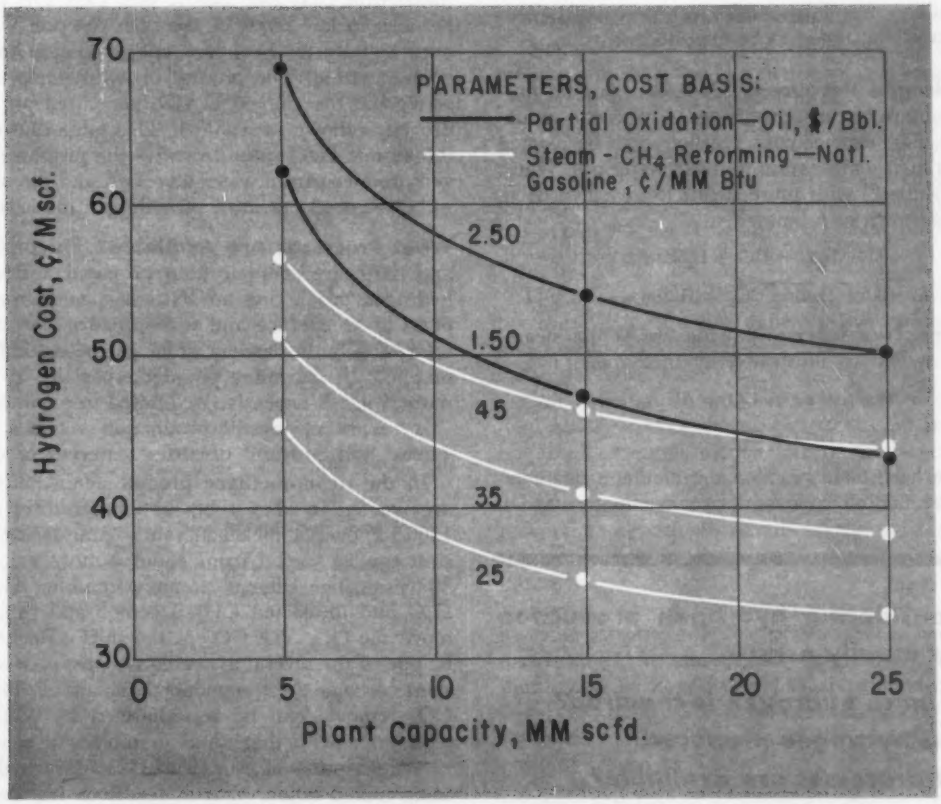

FIGURE 1—The basis for these cost data are given in the text of the report.

"From the point of acceptance and widespread use steam-methane reforming is the leader, while partial-oxidation is becoming popular, especially in areas where natural gas is expensive or limited in availability."

stream. For most refiners the problem of hydrogen has two sides; first recovery from operating units such as catalytic reformers, and second production using one of several available processes.

This article is concerned with the second side of the problem.

WHAT YOU NEED TO KNOW ABOUT HYDROGEN

When considering hydrogen production the refiner usually asks at least four questions:

- How much hydrogen is required?
- How is hydrogen produced?
- What processes are available?
- What is the cost of hydrogen?

Let's attempt to answer these in turn.

How Much Hydrogen Is Required? The hydrogen requirement for a typical refinery operation depends not only on crude thruput but also on the process scheme and extent of hydrogen addition regarded as satisfactory. For thruputs in the range of 45,000 to 50,000 bpcd the consumption of gaseous hydrogen has been shown by Robbers, Paterson and Lane[10] to vary from 6.0 to 46.1 MMscfd (million standard cubic feet per day). This is quite probably the range to be expected.

How Is Hydrogen Produced? Hydrogen can be produced by a variety of reactions, basic to all is the reduction of water. For instance coke (carbon) can be reacted with steam at high temperature to make water gas. Water gas can be "shifted" with more steam to give hydrogen, this scheme is shown as follows:

$$C + H_2O \rightarrow CO + H_2$$

$$CO + H_2O \rightarrow CO_2 + H_2$$

Another reaction scheme in wide use is the steam-hydrocarbon system as illustrated by methane.

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

$$CO + H_2O \rightarrow CO_2 + H_2$$

Like the carbon steam reaction the methane steam reaction is quite endothermic and is conveniently carried out in heated reactor tubes. Although the thermodynamics are favorable at the high temperatures (1300-1500° F) employed, the kinetics are sluggish so that a catalyst is employed.

The catalyst filled tube reactor can be replaced by a refractory lined pressure vessel and by injecting air or oxygen along with methane the endothermic heat may be supplied internally. The basic reactions are similar to steam methane reforming with steam generated from combusting a portion of the feed methane.

Common to all of the reactions noted above are two facts: hydrogen is produced mainly from water, and the primary hydrogen containing stream is always contaminated with CO_2 and usually with CO. The latter can be reduced to low levels by the shift reaction which in turn adds equally to the hydrogen production and the CO_2 contamination. The precent of hydrogen produced from water and the amount of CO_2 generated per mole of hydrogen is shown in Table 1. This table illustrates that as the atomic H/C ratio decreases the proportion of hydrogen produced from water increases, and the moles of CO_2 to be removed per mole of hydrogen made increases.

TABLE 1—Theoretical Yields in Hydrogen Production (Steam-Hydrocarbon Reforming Plus Shift Conversion)

Feedstock	Percent of Hydrogen From Water	Moles CO_2 Made Per Mole H_2	Moles Feedstock Req'd Per Mole of H_2
Methane	50.0	0.250	0.250
Ethane	57.1	0.286	0.143
Propane	60.0	0.300	0.100
Butane	61.5	0.308	0.077
Carbon	100.0	0.500	0.500

What Processes Are Available? The process schemes and hardware configurations proposed and available for hydrogen production are extremely numerous. From the point of acceptance and widespread use stream-methane reforming is the leader, while partial-oxidation (Texaco or Shell) is becoming popular especially in areas where natural gas is expensive or limited in availability.

A review of several production schemes is given by James[4] and Morton[8] discusses materials of construction.

In the steam-methane process steam and natural gas are reacted in alloy tubes at temperatures of 1350° to 1500° F over a nickel alumina catalyst. Reaction pressure can be varied from about atmospheric to close to 300 psig. The effluent stream containing H_2 CO_2, CO, H_2O and unreacted CH_4 is cooled and "shifted" to remove the CO. The CO_2 in the shift effluent is removed by one of the several available systems, such as hot potassium carbonate[1,2,5] or monoethanolamine. Final CO and CO_2 removal can be accomplished by "copper liquor" scrubbing, or methanation[7] or molecular sieves.

A description of American Gilsonite's hydrogen plant using mixed refinery gas as feedstock has been given by Updegraff.[11] A recent article by Kitzen and Tielrooy[6]

"When considering hydrogen production the refiner usually asks:

- ***How much hydrogen is required?***
- ***How is hydrogen produced?***
- ***What processes are available?***
- ***What is the cost of hydrogen?***

discuss the effect of operating variables in steam hydrocarbon reforming.

The partial oxidation process as developed by Texaco and Shell use a pressure vessel to contain the flameless reaction system. Pressures upwards of 500 psig may be used and the reaction temperature is about 2500-2700° F. Effluent is quenched to approximately 600°-700° F before leaving the reactor. An article by Lessing in the May, 1961 issue of "Fortune" includes a colored flow picture of the Texaco system.

From the reactor the gas is scrubbed to remove carbon particles, shifted, and purified in a manner similar to the effluent from a steam-methane reformer furnace.

The partial oxidation process is extremely flexible and feedstocks can vary from natural gas through oil to solids such as coke or coal. About 40 Texaco installations have been made to date. The process has quite a high power requirement due to use of oxygen, but this may be offset by the delivery pressure of 300-500 psig for the product hydrogen. Some carbon is produced in the reactor and this must be eliminated before the gas is passed to the shift converter.

A discussion of the Texaco system was presented at Western Petroleum Refiners Association, Southwest Regional Meeting, January 27-28, 1960.[9]

"These costs do not represent a particular hydrogen plant; they are representative of well designed plants of the types selected."

What's the Cost of Hydrogen? The cost of producing hydrogen requires some manipulation inasmuch as most plants are constructed as a portion of a larger complex and "pure" cases are rarely reported. Fairclough[3] presented data for a variety of schemes in 1956 and the James[4] reference contains some cost data.

For the cost data developed in this article values were taken from these and other literature sources, additionally investment costs were developed for specific cases. The investment costs were correlated against size, and confirmation points were obtained independently. The two processes considered are steam-natural gas reforming at about 125 psig furnace pressure and partial oxidation at about 450 psig reactor pressure. Hydrogen purity is about 96 percent with 4 percent methane content and $CO + CO_2$ in the range of 15 ppm total. Plant sizes considered are 5, 15, and 25 MMscfd.

Operating costs were developed from the literature references supplemented by calculation. No royalty payments are shown for either type plant.

As such these costs *do not* represent a particular hydrogen plant, they are representative of well designed plants of the types selected. Each hydrogen plant must go through critical process and economic evaluation during the design stage so that the final plant best fits the conditions under which it must operate.

The calculated cost for hydrogen is shown in Table 2 for the two production schemes for various plant sizes and raw material costs. The same data is shown graphically in Figure 1.

Cost calculations and economics are areas where the engineer enters with caution because there is at least one more economic theory than there are economists and two more methods of calculating costs than there are combined accountants and financiers. To avoid confusing the readers, the complete details of the calculation will be spelled out—then anyone can substitute his own favorite factor.

First start with the investment. As stated before the investment costs for the plants are a combination of literature values and specific calculations. To these "on-plot" costs were added appropriate investments for the "off-plot" items. The investment summary and the factors used to figure the off-plot investment and operating costs are given in Table 3.

Operating costs are calculated by considering the utility, raw materials, labor, depreciation and other miscel-

TABLE 2—Hydrogen Cost

PROCESS	Cents Per Mscf for Plant Size In MMscfd. 5	15	25
Steam Natural Gas Reforming			
Natural Gas Price, $/MM Btu			
0.25	45.4	35.1	32.4
0.35	51.0	40.7	38.0
0.45	56.5	46.2	43.5
Partial Oxidation-Fuel Oil			
Fuel Oil Price, $/bbl.			
2.50	68.8	53.6	49.6
1.50	62.0	46.8	42.8

TABLE 3—Hydrogen Production Investment

ITEMS	Millions of Dollars for Plant Size In MMscfd. 5	15	25
Steam Methane			
On Plot	1.06	2.30	3.30
Off Plot	.18	.49	.79
Total	1.24	2.79	4.09
Partial Oxidation			
On Plot*	1.78	3.80	5.40
Off Plot	.37	1.02	1.67
Total	2.15	4.82	7.07

Off Plot Factors	Investment	Unit Operating Cost
Steam	4.00 $/lb./hr.	0.80 $/1000 lbs.
Cooling Water	30.0 $/gpm	0.02 $/1000 gal.
Clarified Water	300.0 $/gpm	0.15 $/1000 gal.
Electrical Power	75.0 $/KW	0.008 $/KW Hr.
Miscellaneous	5% on Plant Investment	

* Includes oxygen plant-oxygen consumption approximately 11.0 tons per MMscf of hydrogen.

TABLE 4—Hydrogen Production Operating Factors and Miscellaneous Costs

ITEMS*	Steam-Natural Gas	Partial Oxidation
Process Raw Material	350,000 scf	62 bbl.
Fuel	210 MM Btu	6 bbl.
Steam	36,000 lbs.	60,000 lbs.
Cooling Water	400 gpm	600 gpm
Clarified Water	4.4 gpm	2.0 gpm
Electric Power	62 KW	350 KW
Catalysis & Chemicals	20 $	10 $
Maintenance Materials	2% per year of Total Investment	
Local Taxes and Insurance	2% per year of Total Investment	
Process Royalty	None used	
Depreciation	10% per year of Total Investment	

* Per MMscf or MMscfd of product hydrogen.

TABLE 5—Detailed Costs for Steam Methane Reforming

	Cents Per Mscf for Natural Gas At ¢/MM Btu		
1. Raw Materials and Fuel	**25**	**35**	**45**
Raw Materials	8.79	12.25	15.75
Fuel	5.25	7.40	9.45
Total	14.04	19.65	25.20
	Cents Per Mscf for Plant Size of MMscfd		
2. Other Costs	**5**	**15**	**25**
Utilities (Exclude Fuel)	5.27	5.27	5.27
Catalysts and Chemicals	2.00	2.00	2.00
Maintenance Materials	1.51	1.14	1.00
Local Taxes and Insurance	1.51	1.14	1.00
Depreciation	7.55	5.67	4.97
Labor, Supervision, Overhead	13.50	5.80	4.10
Total	31.34	21.02	18.34
	Cents Per Mscf for Natural Gas At ¢/MM Btu		
3. Total Costs for Plant Size of MMscfd	**25**	**35**	**45**
5	45.4	51.0	56.5
15	35.1	40.7	46.2
25	32.4	38.0	43.5

TABLE 6—Detailed Costs for Partial Oxidation of Residual Oil

	Cents Per Mscf for Residual Oil At $/Bbl.		
1. Raw Materials and Fuel	**2.50**		**1.50**
Raw Materials	15.50		9.30
Fuel	1.50		0.90
Total	17.00		10.20
	Cents Per Mscf for Plant Size of MMscfd		
2. Other Costs	**5**	**15**	**25**
Utilities (Exclude Fuel)	13.28	13.28	13.28
Catalysts and Chemicals	1.00	1.00	1.00
Maintenance Materials	2.62	1.96	1.72
Local Taxes and Insurance	2.62	1.96	1.72
Depreciation	13.11	9.80	8.63
Labor, Supervision, Overheads	19.15	8.56	6.24
Total	51.78	36.56	32.59
	Cents Per Mscf for Residual Oil At $/Bbl.		
3. Total Costs for Plant Size of MMscfd	**2.50**		**1.50**
5	68.8		62.0
15	53.6		46.8
25	49.6		42.8

laneous costs. The factors used in these calculations are shown in Table 4. Maintenance costs were assumed as 4 percent of total investment per year, equally divided between labor and materials.

Labor costs were calculated by providing 3 men per shift for steam-methane reforming and 4 men per shift for partial oxidation. The process labor rate was set at $3.25 per hour. Labor costs then are the process labor plus 2 percent of the investment for maintenance labor. Supervision was calculated at 15 percent of labor, and overheads at 75 percent of labor plus supervision. The total labor plus supervision plus overheads is the cost used in this calculation.

Most of the equipment in hydrogen plants in the size range used in this study are of the "single train" type, that is a single piece of equipment can be built large enough for the capacity indicated. An exception would be the partial oxidation reactors, which are usually built in "half size" units with an additional spare reactor, so that three interconnected vessels form the building block. This reactor configuration provides full capacity in the event of refractory or burner troubles. It is conceivable that partial oxidation systems could be built with capacities of 100 MMscfd as a single train.

Steam methane plants larger than 30 MMscfd require two furnaces. The remainder of the equipment is single train up to about 50 MMscfd and 100 MMscfd single train units may be possible.

At this point the calculations for hydrogen cost appear as detailed in Tables 5 and 6. The complete breakdown is shown as well as the variation with fuel costs. No return on investment or allowance for profit is shown because these factors depend on the management philosophy of each particular enterprise.

The costs presented here show that with the economic assumptions made the partial oxidation system can compete with steam-methane reforming in plants of about 15 MMscfd of capacity when the fuel oil cost is about $1.50 per barrel and natural gas is about $0.45 per MMBtu. The cost will show more favor to partial oxidation when the investment and operating costs of compressing the steam reformer product from 125 psig to 450 psig are included in the analysis.

The investment costs for the partial oxidation system must include the air separation plant for the oxygen requirement or charge in purchased oxygen as a raw material. If no return can be obtained for the nitrogen stream the added investment and operating costs create a difficult burden for the partial oxidation system to overcome as far as hydrogen production is concerned.

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Key Words for Indexing

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About the Author

Ertel

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Now Condensate Can Be Hydrocracked, Too

Together, Isocracking and catalytic reforming offer a worthwhile way to improve the value of natural gasoline condensate. Look over this economic analysis of an illustrative case to see how these two processes go hand-in-hand

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Condensate stocks can be hydrocracked in the field or in a distant refinery. The best economics may be found in refineries where condensate is only one of several hydrocracking feed stocks and where larger size plants could be built. However, to demonstrate the advantages now available with hydrocracking processes, a brief evaluation is presented for a typical Isocracking application in a 60-million standard cubic foot per day gas plant producing 7,600 bpcd of full boiling-range condensate.

The illustrative example shows an investment of about seven million dollars for process facilities pays out in about four years after taxes. The gas plant product realization is increased by over $5 million annually. This is possible because gasoline quality is improved sufficiently to permit segregation and marketing of significant volumes of premium as well as regular gasoline.

WHAT CONDENSATE FACES

Currently, condensates and gas-liquids generally find their way into a crude oil pipe line where they are mixed and blended off with crude oil. Whether gas plant condensates are best converted to marketable products by concurrent refining with crude oil via conventional methods or in a separate processing plant via hydrocracking is the subject of this discussion.

Up to a few years ago, the gas plant operator had essentially one refining process that he could afford to install for upgrading his condensate liquids, namely, catalytic reforming. Because the reformer feed stock volume usually available is small, few reformers have been installed in field processing plants. However, the introduction of Isocracking may alter these earlier conclusions. A larger portion of the condensate can now be processed resulting in larger plant sizes and lower unit costs. Furthermore, a larger volume of high octane gasoline can be produced without formation of low value gas by-products.

Recent gas-condensate discoveries in Texas and Louisiana and the current construction of large pipe lines for export of natural gas from Alberta into the United States increases the importance of the question of how best to dispose of the heavier by-product liquid hydrocarbons that must be produced when these new resources are opened up.

The volume of these materials in 1960 was substantial according to the API and the U.S. Bureau of Mines. Their data are summarized in Table 1. A substantial portion of this total condsensate boils above the gasoline range.

TABLE 1—Condensates in 1960

	BARRELS PER DAY	
	United States	Canada
Field Plant Condensate (Excluding LPG)	250,000–280,000	20,000
Cycle Plant Condensate	60,000– 70,000	10,000–15,000
Natural Gasoline	260,000–270,000	
Total	570,000–620,000	30,000–35,000

The production of gas liquids in Canada shortly will expand by 50,000 to 60,000 barrels a day as plants supplying the new West Coast gas lines are brought on stream. Eventually the total Canadian production may reach around 100,000 Bpd. Most of this production will be in Western Alberta. Perhaps a ten percent increase in the U.S. production of these materials may be in prospect. Most of the U.S. production is in northeast Texas and in Louisiana.

HOW HYDROCRACKING FITS IN

In October 1959, California Research Corporation announced a major new petroleum refining process called Isocracking. Isocracking is a hydrocracking process. It is a particularly efficient method for converting distillate stocks to over 100 percent yield of high octane gasoline. As a by-product, Isocracking also makes 10 to 15 percent yields of isobutane. Little or no light gas is produced.

There are valuable uses for Isocracking in the area of natural gasoline plant operations. In such an application, the natural gasoline plant can employ Isocracking to convert all of the low value heavy end of the condensate into high octane gasoline. Main results of this conversion

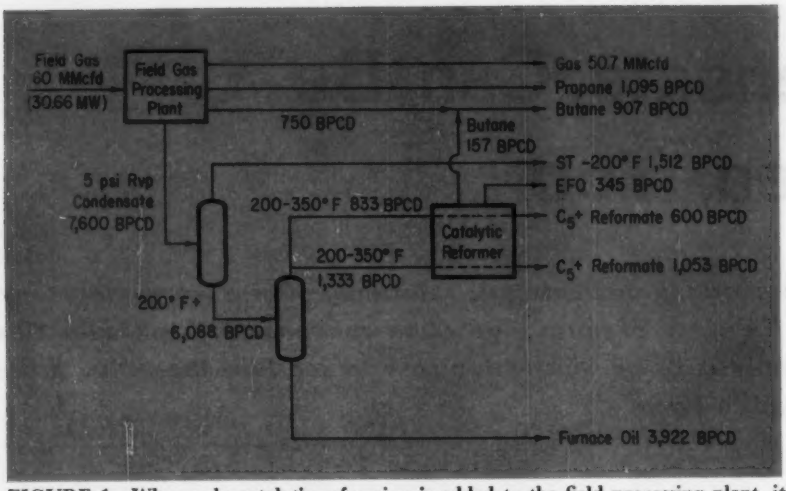

FIGURE 1—When only catalytic reforming is added to the field processing plant, it is used on blocked operation: 833 bpcd at 72 LV% of C_5 plus having 104 F-1 at 3 ml TEL and 1,333 bpcd at 79 LV% of C_5 plus having 102 F-1 at 3 ml TEL. Then the two grades of gasoline will be: 800 bpcd premium having 100 F-1 at 3 ml TEL and 2,441 bpcd regular having 91.5 F-1 at 3 ml TEL. Both grades will have 9.5 psi Rvp.

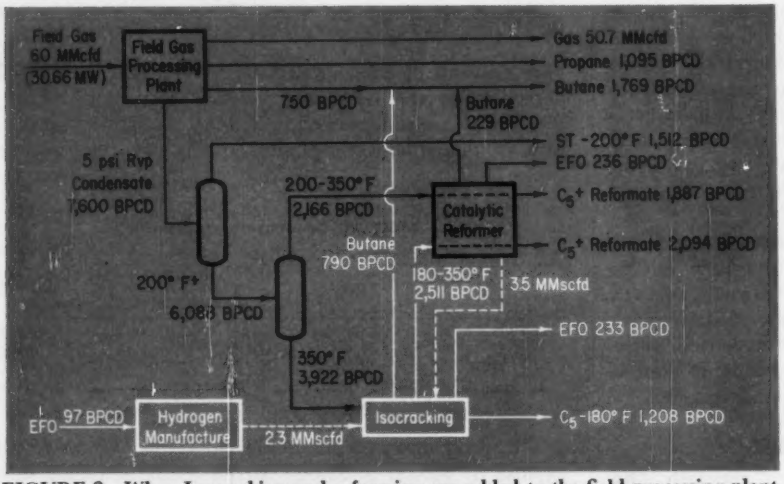

FIGURE 2—When Isocracking and reforming are added to the field processing plant, the reformer will be on blocked operation: 2,511 bpcd at 83.4 LV% of C_5 plus having 99.7 F-1 at 3 ml TEL and 2,166 bpcd at 87.1 LV% of C_5 plus having 97.5 F-1 at 3 ml TEL. Then the two grades of gasoline will be: 3,440 bpcd premium having 100 F-1 at 3 ml TEL and 3,509 bpcd regular with 91.5 F-1 at 3 ml TEL and 9.5 psi Rvp.

are to: first, upgrade the over-all plant product realization, and second, improve the gasoline quality.

The composition and properties of condensates will vary widely depending primarily upon the physical state of the field producing reservoir. Of interest from an Isocracking viewpoint is the amount of C_9 plus material in the recovered gas plant liquid. Broadly speaking, condensates can be classified into two categories as: gasoline condensates and full-boiling condensates. Examples of each type are shown in Table 2.

Typically, the C_5 to 200° F light naphtha cut has a leaded F-1 octane number of 80 to 85 and is an acceptable gasoline blend stock. The 200 to 400° F heavy naphtha cut is marginal. It will run around 65 F-1 with 3 ml TEL. In particular, the 330° F to 405° F material is poor gasoline stock because of its very low octane. The 200° to 330-350° F cut-point stock can be reformed to acceptable regular grade gasoline blend stock in reasonable yields. The 330° to 530° F cut from condensates frequently will not meet smoke-point or freeze-point specifications for jet fuel. The gas oil cut up to 600°-650° F generally is satisfactory for stove oil and No. 2 Oil. However, gas oil stocks from certain condensates will have sulfur and pour point problems. Consequently, the refiner or processing plant operator may need ways to upgrade the gas oil components in condensate boiling above 330°-350° F.

Potential interest for Isocracking occurs where the volume of 330° F plus gas oil is large enough to justify

TABLE 2—CONDENSATE PROPERTIES

	GASOLINE CONDENSATE				FULL BOILING CONDENSATE					
	Homeglen Rimbey Alberta		Woods County Texas		S.E. Marietta Oklahoma		Cass County Texas		Windfall Alberta	
	Whole	350 °F. + Fraction	Whole	350 °F. + Fraction	Whole	350 °F. + Fraction	Whole	350 °F. + Fraction	Whole	350 °F. + Fraction
Yield, LV%	100	12	100	18	100	51	100	45	100	28
Gravity, °API	64	42	59	35	55	41	54	38	58	48.5
Aniline Point, °F	135	148	114	118	160	180	143	172	140	155
Sulfur, Wt. %	0.04	0.15	0.09	0.20	0.12	0.3	0.5	0.8	0.38	0.50
Nitrogen, ppm. Total	6	21	10	31	25	69	3	16	11	33
ASTM Distillation, °F	D86	D158	D86	D158	D86	D158	D86	D1160	D86	D158
IBP	92	352	89	335	89	361	88	387	109	361
10	135	373	134	362	152	396	163	422	170	381
30	186	387	189	382	255	451	246	462	231	415
50	228	409	234	413	349	521	320	533	290	450
70	278	441	285	476	485	629	430	620	398	515
80	316	460	350	530	576	670	.....	.....	504	.....
90	393	495	409	585	.....	765	.....	757	.....	648
EP	512	612	580	702	660	> 800	580	950	660	752
% Rec.	96	99	97.5	97.5	88	.....	85	99	88	99

TABLE 3—Catalytic Reforming Added to a 60-Million SCF/D Gas Plant

Processing Plant Investment	
Distillation Equipment	$ 300,000
Catalytic Reformer	1,150,000
Total On-Plot	$1,450,000
Off-Plot	450,000
Total Investment	$1,900,000

	$/Bbl.	bpcd	$/Year
Product Realizations			
Fuel Gas—EFO	1.00	345	126,000
Mixed C4's	2.94	81	87,000
Gasoline (9.5 RVP)			
Premium (100 F-1 at 3 ml TEL)	5.25	800	1,530,000
Regular (91.5 F-1 at 3 ml TEL)	4.41	2,441	3,930,000
Furnace Oil	2.73	3,922	3,910,000
Sub Total		7,589	$9,583,000
Inputs			
Condensate	2.90	7,600	8,040,000
TEL	(2.20/ltr.)	(408 ltr.)	330,000
Sub Total			$8,370,000
Operating Costs			
Distillation	0.05		140,000
Reformer	0.42		330,000
Sub Total			$470,000
Amount Available for Payout			$743,000

Payout	
Before Income Taxes and Depreciation	2.6 Years
After 52% Taxes and 10% Straight Line Depreciation	4.2 Years
Cash Position at five years before tax	$1,810,000

a reasonable size plant. As indicated on Table 2, the "gasoline condensates" do not contain enough gas oil components and therefore are not attractive stocks for Isocracking; they are more attractive as potential feed stocks for catalytic reforming.

The "full-boiling condensates" are well suited to Isocracking. In the latter case, the processing plant would produce only high quality gasoline with a market value of the order of $4.50 to $5. a barrel. Whole condensate presently brings only about $2.75 to $3 a barrel.

To summarize, condensates of interest for Isocracking will be of the full-boiling type containing about 35 percent to perhaps as much as 60 percent of 330° F plus gas oil material. These gas oils characteristically will have: about 35 to 40-degree API gravity, a high aniline point (paraffinic nature), and a modest nitrogen content. Their sulfur content will vary from field to field. However, sulfur is not a critical consideration with Isocracking.

TABLE 4—Estimated Yields

PROCESS YIELDS	Wt. Percent Of Input Hydrocarbon	RAW FEED BASIS Lb. Per 100 Bbl.	RAW FEED BASIS Bbl. Per 100 Bbl.
Hydrofining*			
H_2S	0.13	37	....
NH_3	0.01	3	....
C_1	0.05	14	....
C_2	0.07	20	....
C_3	0.09	26	....
C_4	0.10	29	....
C_5-200 °F	99.92	28,680	100.5
200-400 °F			
400 °F+			
Total	100.37	28,809	....
Isocracking*			
C_1	0.02	6	....
C_2	0.19	54	....
C_3	4.0	1,146	....
iC_4	10.5	3,011	15.3
nC_4	4.2	1,205	5.9
C_5-180 °F	24.7	7,084	30.8
180-350 °F	58.25	16,710	64.0
Total	101.86	29,216	116.0

* Hydrogen Consumption is 200 scf/Bbl for Hydrofining and 1,000 scf/Bbl for Isocracking.

AN ILLUSTRATIVE EXAMPLE

Reforming Alone. Figure 1 shows what can be done with catalytic reforming alone in upgrading Oklahoma condensate. Facilities are installed at the field processing plant to separate and catalytically reform the 200° to 350° F boiling range stock in this five pound condensate. The reformate is blended with C_4 to 200° F light natural gasoline to give a gasoline product which could be marketed as regular grade gasoline. Premium grade gasoline also could be made by reforming more severely. However, the loss in gasoline yield and higher costs are substantial penalties. The 350° F plus gas-oil cut is assumed to be sold as furnace oil.

Typical economics for such a project are shown on Table 3.

Hydrocracking and Reforming. Figure 2 shows how the same condensate is upgraded by installing both Isocracking and catalytic reforming. Facilities are provided to separate the 200° to 350° F boiling range stock for catalytic reforming. The 350° F plus stock is Isocracked and the 180° to 350° F heavy Isocrackate also is catalytically reformed. The reformate is blended with the C_4 to 200° F light natural gasoline to make both premium and regular grade gasolines. Reforming is conducted in blocked operation at two severities to make blend stocks for the two grades of gasoline.

Estimated yields, product qualities and hydrogen consumptions for hydrofining and Isocracking the 350° F plus condensate stock are shown in Tables 4 and 5. This portion of the plant would produce a 94.8 LV% yield of C_5 to 350° F gasoline stock from feed. The C_4 plus products total 116.0 LV%.

The C_5 to 180° F light Isocrackate is 100 F-1 octane with 3 ml TEL and has zero to negative sensitivity. It

TABLE 5—Product Quality

INSPECTION	Stock	Raw Feed	Hydrofined Stock	Light Isocrackate C_5-180 °F	Heavy Isocrackate 180-350 °F
Gravity, °API		40.9	42	84	58
Aniline Point, °F		180	..	....	130
ASTM Distillation, °F		(D158)	..	(D86)	(D86)
IBP		361	..	95	215
10		396	..	100	235
30		451	..	....	....
50		521	..	140	260
70		629	..	....	....
90		765	..	150	320
EP		800	..	190	360
Composition, LV Percent					
Paraffins		45	..	82	60
Naphthenes		42	..	12	30
Olefins		.....	..	....	....
Aromatics		13	..	6	10
Total		100	..	100	100
Sulfur, Wt. Percent		0.12	..	....	....
Nitrogen, ppm					
Basic/Total		—/69			
Octane Numbers					
F-1 Clear				89	54
F-1 + 3ml TEL/Gal				100	76
F-2 + 3ml TEL/Gal				101	78
F-1 + 3 ml TEL/Gal. After Reforming to 83.4 Cs + LV Percent Yield					99.7

TABLE 6—Composition of Light Isocrackate

Component	Vol. %
Benzene	4
Isopentane	47
Isohexanes	28
Isoheptanes	3
Normal pentane	4
Normal hexane	2
Methylcyclopentane	10
Miscellaneous	2
Total	100

TABLE 7—Isocracking and Catalytic Reforming Added to a 60-Million SCF/D Gas Plant

Processing Plant Investment			
Distillation Equipment	$ 300,000		
HDN Unit	850,000		
Isocracker	1,900,000		
Catalytic Reformer	1,600,000		
H_2 Manufacture	550,000		
Total On-Plot	$5,200,000		
Total Off-Plot	2,000,000		
Total Investment	$7,200,000		
	$/Bbl.	**bpcd**	**$/Year**
Product Realizations			
Fuel Gas—EFO	1.00	372	$ 136,000
Mixed C4's	2.94	771	830,000
Gasoline (9.5 RVP)			
Premium (100 F-1 at 3 ml TEL)	5.25	3,440	6,590,000
Regular (91.5 F-1 at 3 ml TEL)	4.41	3,509	5,650,000
Sub Total		8,092	$13,206,000
Inputs			
Condensate	2.90	7,600	$8,040,000
TEL	(2.20/ltr.)	(875 ltr.)	700,000
Sub Total			$8,740,000
Operating Costs			
Distillation	0.05		$ 140,000
HDN Unit	0.18		260,000
Isocracker	0.38		550,000
Catalytic Reformer	0.30		510,000
Hydrogen Plant	(25¢/MSCF)		210,000
Sub Total			$1,670,000
Amount Available for Payout			$2,796,000
Payout			
Before Income Taxes and Depreciation			2.6 Years
After 52% Taxes and 10% Straight Line Depreciation			4.2 Years
Cash Position at 5 Years Before Tax			$6,770,000

is sulfur, olefin and nitrogen free. These properties make it a valuable gasoline blend stock. Its octane blending characteristics are similar to those of other isoparaffins such as alkylate and isopentane. The blending values for light Isocrackate approach those for isopentane despite the fact that isopentane rates five to six numbers higher in leaded octane. Analysis of a typical light Isocrackate shows it to be composed largely of isoparaffins as reported in Table 6.

The 180° to 350° F heavy Isocrackate is sulfur and nitrogen free and can be fed directly to reforming without further treatment. It will reform to 99.7 F-1 with 3 ml TEL at 83.4 LV% yield.

The hydrogen consumption for hydrofining and Isocracking condensate is quite low. It will be of the order of 1,500 scf per barrel of fresh feed including allowances for hydrogen dissolved in liquid products and losses. A portion of this hydrogen is returned from catalytic reforming. The combined reforming and Isocracking operations will show a net consumption of hydrogen. Consequently, a manufacturing plant of 2.6 million scf hydrogen per stream day is required to bring the project into hydrogen balance. This latter facility might be eliminated where condensate Isocracking is conducted in a refinery where hydrogen is available.

The economics for installing Isocracking and reforming together to upgrade condensate summarized in Table 7, show that an investment of about $7 million for process facilities would pay out in about four years after taxes.

By installing these processing facilities, the gas-plant product realization is increased by approximately $5,200,000 annually. Gasoline quality is improved sufficiently to permit segregation and marketing of significant volumes of premium as well as regular gasoline.

The foregoing economic analyses are illustrative only. The refiner or gas plant operator can substitute his own stock values and costs to fit his particular situation. The important consideration to keep in mind is the differential value between gas oil and gasoline. It is this differential that is the driving force to pay out the investment. Further, the differential stock value required to support an Isocracking project becomes smaller as the plant size is increased.

Where condensate is an incremental feed stock for an Isocracker justified on conversion of cycle oils and refinery distillates, the economics will look even more attractive than presented in this analysis.

Key Words for Indexing

Condensates
Costs
Cracking (chemical)
Economics
Hydrogen
Hydrogenation
Investments
Reforming

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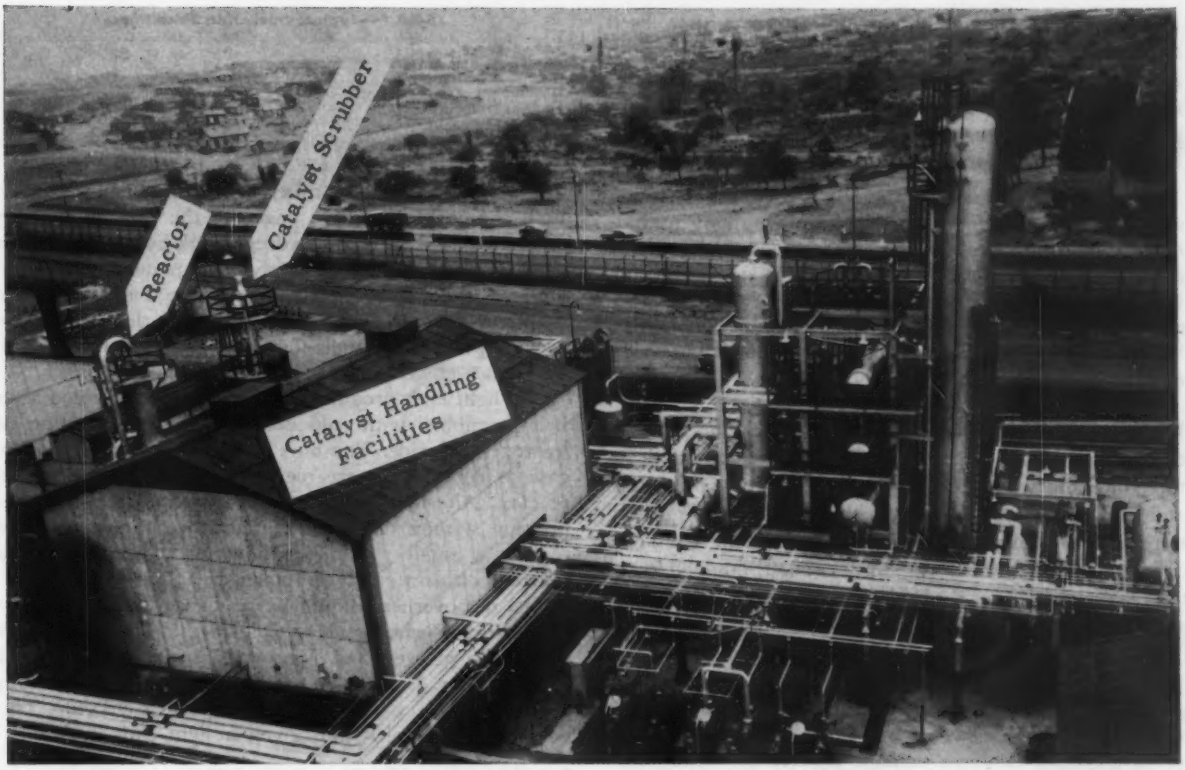

FIGURE 1—New reactor system was tested on a commercial scale early in 1961 at the refinery of Shell Curacao, N.V.

Isomerize Pentane With This New Reactor System

Commercial and pilot plant tests demonstrate the success of a new reactor system for isomerizing pentane. Originally developed for butane isomerization, the new system is shown also to give high yields of isopentane on a single pass basis

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A new reactor system proves its ability to give single pass isomerization of pentanes to 75 weight percent isopentane (based on paraffinic pentanes). Thus, the system offers an advantage over the high temperature hydroisomerization processes (700-900° F) currently available which yield 50-60 percent because of the less favorable equilibrium at the higher temperatures. The higher conversion levels of the new system give important savings in deisopentanizer costs for a recycle isomerization process and in many instances will make it attractive to isomerize straight run C_5's in once-through operation.

Isomerization Improved

A substantial improvement has been announced[1] regarding conversion in the liquid phase process for isomerizing n-butane, accomplished by use of improved

reactor design. The new reactor type has now been applied in pentane isomerization. Extensive testing both in a pilot plant and in a large scale commercial plant has demonstrated that near equilibrium conversion of n-pentane to isopentane can be accomplished in the Shell Liquid Phase process using the improved reactor design.

In the Shell process the catalyst is a liquid consisting of a solution of aluminum chloride in antimony trichloride. Anhydrous hydrogen chloride is added to the system as a catalyst promoter. The catalyst is active at low temperatures, where the equilibria favors isopentane formation. For pentane isomerization a small amount of hydrogen is circulated to suppress disproportionation reactions.

The process flow is illustrated in Figure 2. The pentane charge first passes through an activated alumina drier to reduce the water content, then, through a preheater and into the bottom section of the scrubber column. In the scrubber column the rising feed stream contacts, countercurrently, a small stream of catalyst, pumped from the reactor, to extract the antimony trichloride and active aluminum chloride while rejecting a small amount of insoluble aluminum chloride complex.

This complex or sludge arises from reactions of catalyst with feed impurities or as a result of the minor amount of side reactions that accompany isomerization. The ability to maintain constant catalyst activity by continuous addition of active catalyst and withdrawal of complexed catalyst is an attractive feature of the liquid phase process.

The feed from the scrubber, containing recovered catalyst components, now contacts the hydrogen and hydrogen chloride recycle streams and enters the reactor. A close approach to equilibrium isopentane is achieved in the reactor. A range of feasible operating conditions are indicated in Table 1.

TABLE 1—Typical Operating Conditions

Reactor Temperature, °F	176–212
Reactor Pressure, psig	300
HCl in Feed, weight percent	5
H_2 in Feed, mole percent	1–2
$AlCl_3$ in catalyst, weight percent	3–4

The reacted pentane mixture which is now saturated with catalyst components passes to the catalyst recovery column. The isomerizate, hydrogen and hydrogen chloride are taken overhead and catalyst components are recovered as bottom product for recycle to the reactor. To maintain catalyst activity, a portion of the catalyst recycle is pumped through the make-up vessel where fresh aluminum chloride is added to the catalyst phase.

Net light ends produced in the process are vented after being scrubbed with cold isomerizate to prevent loss of hydrogen chloride. The bulk of the hydrogen and other gaseous components are recycled by compression to the reactor. Alternatively, the hydrogen recycle gas compression systems can be eliminated by supplying to the reactor a small continuous flow of hydrogen from a source such as a catalytic reformer.

The net overhead liquid passes to the hydrogen chloride stripper where the hydrogen chloride along with dissolved hydrogen and light ends is recycled overhead to the reactor. Isomerizate product is recovered as column bottoms and is essentially free of hydrogen chloride. The isomerizate is cooled and given a light soda treat.

A new reactor is the principal departure from usual design although other improvements in design and instrumentation have also been made. Earlier designs utilizing a stirred contactor were unable to exceed 55-60 wt % isopentane (basis non-cyclic pentanes). The new reaction system, however, is able to achieve a close approach to equilibrium. Continuous operation at product C_5 ratios ($iC_5/C_5 + nC_5$) of 75 wt % isopentane is now entirely practical.

Why the interest in Pentane Isomerization?

The Shell Liquid Phase process for isomerizing *n*-pentane was first used[2] by Tidewater Associated Oil Company (now Tidewater Oil Co.), starting in 1944, to produce isopentane for aviation gasoline blending. Shortly after the war ended, however, the supply of naturally ocurring isopentane became adequate to meet aviation gasoline demand and interest in synthesizing isopentane declined. There was no economic incentive for isomerizing *n*-pentane for use in motor gasoline at that time because octane ratings for gasolines were low, and *n*-pentane itself was considered a good gasoline component.

In the last few years, however, the octane ratings of motor gasoline have increased rapidly and *n*-pentane with its leaded F-1 and F-2 ratings of 84.8 and 84.2, respectively, is one of the lower octane components of the gasoline pool. In spite of its low octane rating, some refiners are forced to blend *n*-pentane along with other light straight run components into premium grade gasoline for sensitivity control. In addition, increasing quantities of natural gasolines and condensates are becoming available. These, of course, contain substantial quantities of *n*-pentane. The leaded F-1 and F-2 octane ratings of isopentane are about 24 units higher than for *n*-pentane. Although the octane ratings of isopentane are generally depreciated when blending in present day premium gasolines, it still may be expected to have leaded blending octane numbers in the range 100-104 depending upon premium gasoline composition. Hence, converting the *n*-pentane in the refinery to isopentane by isomerization would (1) permit a substantial increase in pool octane rating and (2) provide a superior blending component for increasing the octane rating and reducing the sensitivity of premium gasoline.

It is anticipated that isomerization processes will become increasingly attractive in the future because of:

- The large octane increase that can be accomplished
- The desirability of isopentane as a blending component for premium gasoline
- The increasing stocks of low octane natural gasolines and condensates
- The continuing demand for higher octane fuels.

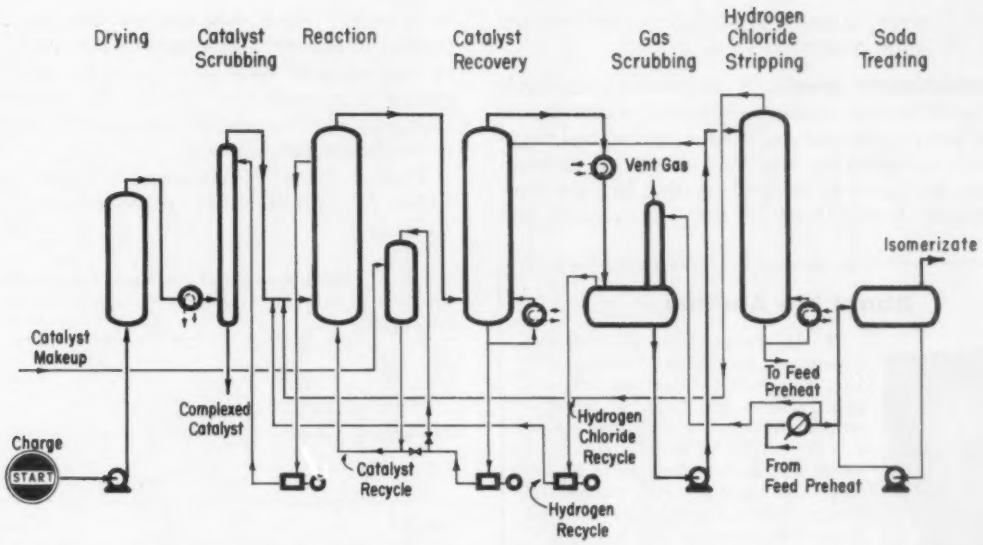

FIGURE 2—Tests demonstrate that near equilibrium conversion of n-pentane to isopentane can be accomplished.

COMMERCIAL SCALE TEST MADE

Following extensive piloting of the improved pentane isomerization process, the process was tested on a commercial scale early in 1961 at the refinery of Shell Curacao, N.V. at Curacao, Netherlands Antilles. In order to make the tests, the new type of reactor and a hydrogen recycle compressor system were installed in an existing Shell Liquid Phase isomerization plant which had been operating for butane isomerization since 1952 (although designed originally during the war years for making isopentane for aviation gasoline).

A photograph of the Curacao plant is shown in Figure 1. The top portions of the scrubber column and of the new reactor can be seen projecting through the roof of the shed housing the catalyst handling facilities and the hydrogen compressor system.

A wide range of process conditions was studied in commercial operation including feed rates up to 3,500 bpd, feed olefin contents up to 0.08 wt % and variations in flow rates of hydrogen, HCl, catalyst make-up rates as well as variations in reactor temperatures and pressures in order to establish optimum operating conditions.

PERFORMANCE CHARACTERISTICS ARE GOOD

Conversion Level and Yields. The compositions of feed, HCl stripper bottoms and vent gas for one of the commercial test runs are shown in Table 2. It will be noted that the product averaged 75 percent isopentane based on paraffin C_5's. At times during the test run conversion approached 80 percent isopentane.

The average net production of disproportionation products lighter and heavier than pentanes during this test run were 1.3 wt % and 1.0 wt %, respectively. As will be noted from Table 2 the butanes produced were almost entirely isobutane. A substantial portion of the hexanes produced are dibranched isomers so that this fraction is expected to have an excellent octane rating. The portion of the feed converted to propane and lighter material and to catalyst sludge totaled less than 0.1 wt %. Hence the yield of C_4^+ product is nearly 100 percent on a weight basis and somewhat over 100 percent on a volume basis.

The commercial scale tests were made with feeds containing roughly 30-35 percent isopentane. The yield structure for feeds containing lesser amounts of isopentane, based on pilot plant studies, are about the same as is shown in Table 3. However, somewhat lower space veloci-

TABLE 2—Stream Compositions for Commercial Test of Pentane Isomerization

COMPONENT	COMPOSITION		
	Feed[a] Weight Percent	Product[b] Weight Percent	Vent Gas[c] Mole Percent
Hydrogen	....	.....	86
Hydrogen chloride	....	<0.001	<0.1
Methane	....	.....	1.0
Ethane	....	.....	<0.1
Propane	....	<0.1	0.2
Isobutane	....	1.3	1.2
n-Butane	....	<0.1	0.1
Iso Pentane	31.2	70	9.2
n-Pentane	64.6	23.5	2.2
Cyclopentane and heavier	4.2	5.2	0.1
	100	100	100

[a] Sulfur <0.001 weight percent, olefins 0.02–0.03 weight percent.
[b] Before caustic treating.
[c] Venting only periodically.

TABLE 3—Pilot Plant Feed and Product Compositions

COMPONENT	COMPOSITION, WEIGHT PERCENT			
	n-C_5 Feed[a,b]		Mixed nC_5/iC_5 Feed[a]	
	Feed	Product	Feed	Product
Propane and lighter	0	<0.1	0	0.2
Isobutane	0	1.6	0	1.6
n-Butane	0	0.1	1.0	1.0
Iso pentane	0.9	69.1	29.2	68.8
n-Pentane	96.1	24.7	67.0	24.3
Cyclopentane and heavier	3.0	4.5	2.8	4.1
Total	100	100	100	100

[a] Olefins <0.01 weight percent.
[b] Sulfur 0.0002 weight percent.

ties or, alternatively, higher free $AlCl_3$ levels are required to obtain the same conversion level.

Feed Contaminants Levels. Water, sulfur compounds and olefins all increase catalyst consumption and should be held to practical minimum levels. Conventional treating methods are adequate. The Shell process can accomodate temporary upsets in the feed treating facilities since in the reactor section most of the contaminants will be removed before they can get into the reactor. The amount of hexanes accompanying pentane feeds obtained by conventional distillation cause no problems in the process. The hexanes will, in fact, be upgraded in octane rating due to conversion of n-hexane and methyl pentanes to the dibranched isomers.

Typical chemical consumption figures are given in Table 4. Typical utility requirements are shown in Table 5.

TABLE 4—Typical Chemicals Consumption

CHEMICAL	Lb/bbl Charge
$AlCl_3$	0.20
$SbCl_3$	0.03
HCl	0.02
H_2	(6 scf/bbl)

TABLE 5—Utilities

UTILITY	Per bbl Charge
Steam, @ 200 psig, lb	50
@ 100 psig, lb	55
Cooling water (30° F rise), gallon	380
Power, kwh	0.65

Based on Shell's long experience with butane isomerization, on-stream times exceeding 95% are anticipated for pentane isomerization.

FRACTIONATION COSTS ARE REDUCED

The 75 percent isopentane product, basis paraffin C_5's, which can be produced by the Shell process is better than the 50-60 percent which can be produced by high temperature (700-900° F) hydroisomerization processes where thermodynamic equilibrium is less favorable. As a result of the higher conversion the extensive fractionation costs normally associated with pentane isomerization will be greatly reduced. For example, in recycle isomerization to produce isopentane at say 90-95 percent purity the cost of the deisopentanizer is generally much greater than the cost of the isomerization plant. Higher conversion levels will reduce the recycle rate and hence the feed rate to both the isomerization plant and the deisopentanizer. At the same time, an easier separation in the deisopentanizer is possible because the feed stream is more concentrated in isopentane. Also, at the higher conversion levels it is now feasible to consider once-through isomerization of n-pentane or even mixed C_5's from straight run or natural gasoline, eliminating the deisopentanizer and therefore reducing the cost of the over-all process by as much as 60-65 percent in some instances—still obtaining 50 to 75 percent of the octane potential of recycle isomerization.

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The authors wish to acknowledge the valuable contributions of the many persons at Shell Development Co., Shell Oil Co., Dominguez Refinery, Shell Curacao, N.V. and Bataafse International Petroleum Maatschappij, N.V. which have led to the development of the improved Shell Liquid Phase Isomerization process.

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Key Words for Indexing

Design, Isomerization, Isopentane, Pentane, Reactors

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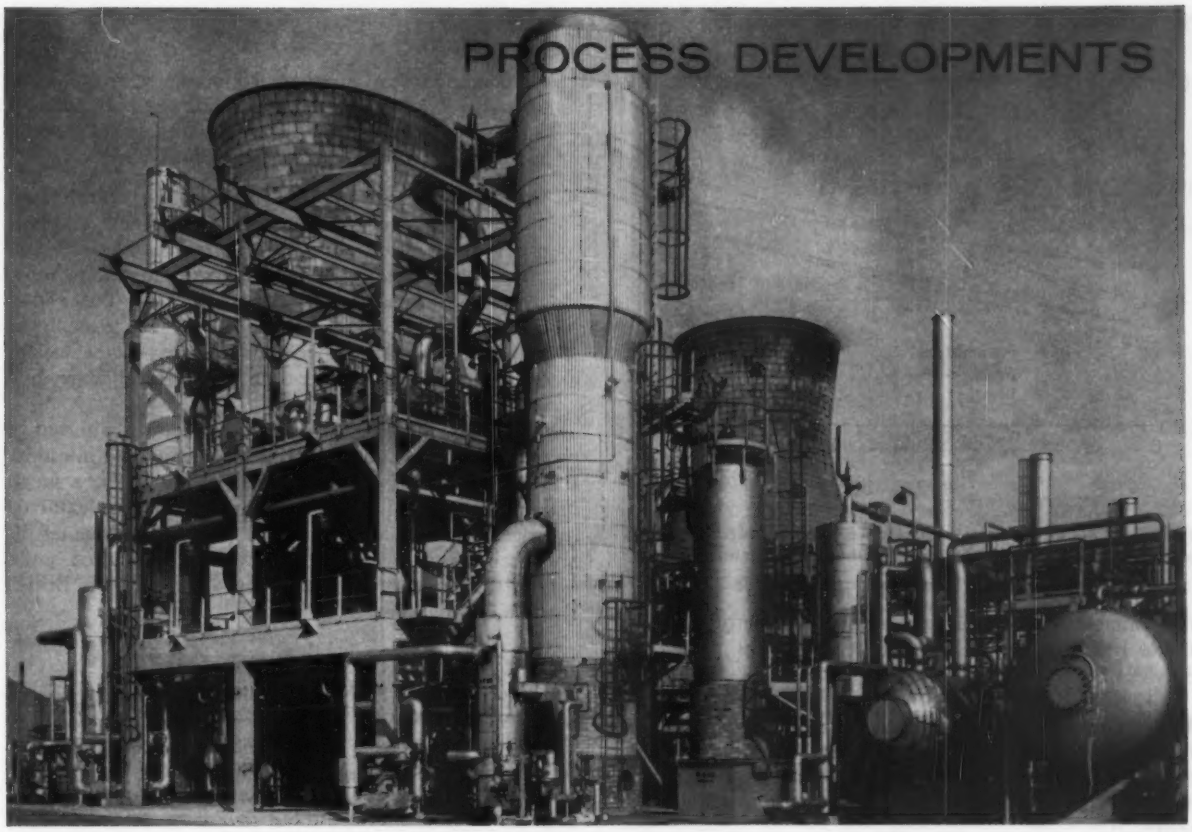

FIGURE 1—More units are projected or in an advanced state of design.

New Hydrotreating Process Now in Commercial Operation

BP now has three units of its selective hydrogenation process installed with more units on the way. See how the process upgrades the gasoline byproduct from ethylene manufacture

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Last year, three units using the BP Selective Hydrogenation process were commissioned by BP associated petroleum chemical companies in the United Kingdom, West Germany and France. The catalyst life in all these plants exceeds six months and the units continue to give good service and trouble-free operation.

A view of the 8,500-bpsd unit installed at Grangemouth by British Hydrocarbon Chemicals Limited is shown in Figure 1. Further units are projected or in an advanced state of design. Commercial experience and further development work have led to a simplification of the process and engineering design of the new units which will result in a significant reduction in capital and operating costs.

THE NEED FOR HYDROGENATION

In recent years, there has been a spectacular worldwide expansion in the production of ethylene by pyrolysis of hydrocarbons. In regions where natural gas is not read-

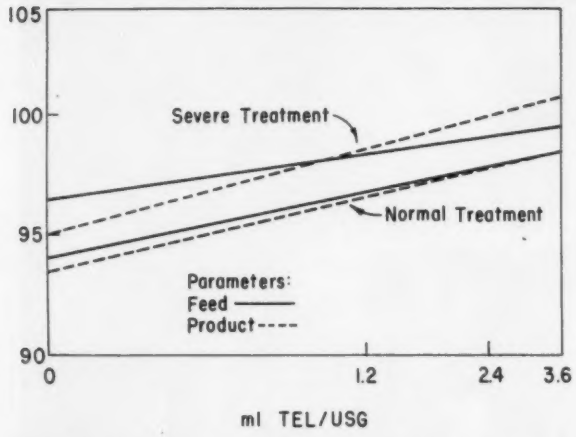

FIGURE 2—There is a small loss in the unleaded Research octane rating, but the product has a better lead response.

ily available, particularly in Europe, light petroleum distillate fractions are the favored feedstock for producing ethylene.[1]

The value of the byproducts, especially that of high octane pyrolysis gasoline plays an important part in the economics of ethylene manufacture produced by pyrolysis of light naphthas and often determines the cracking pattern.[1]

In all situations where there is a market for pyrolysis gasoline, two factors affect the value of this byproduct.

- **The necessity for refining** the highly unstable pyrolysis gasoline into a marketable blending component or finished motor gasoline. The considerable growth of light naphtha pyrolysis has made the gasoline byproduct a major component in motor gasoline production such that it cannot be marketed without applying to it à positive refining treatment. The refining costs of this treatment have therefore been charged against the value of pyrolysis gasoline.
- **The recovery of gasoline** from the refining treatment. Existing conventional processes such as phosphoric acid or clay treatment produce adequate improvement in quality by polymerizing the gum forming compounds present in pyrolysis gasoline but consequently result in substantial losses of gasoline as polymer, typically 10 percent to 15 percent by weight on feed. These processes thus lead to smaller product realization.

There has therefore been a need for an alternative equally effective refining treatment which would minimize the degradation of gasoline to fuel oil by giving a much higher recovery of treated product. Selective catalytic hydrogenation would be expected to produce these results and such a process[2] has been developed, designed, engineered and put into commercial operation by British Petroleum.

QUALITY OF HYDROGENATED PYROLYSIS GASOLINE

Typical inspection data are given in Table 1 and 2 which show that the finished gasolines are of excellent stability. Octane number determinations show that there is a small loss in the unleaded Research octane rating as a result of this treatment, but owing to the better lead response of the hydrotreated product, there is no loss in leaded octane number (Figure 2). It is possible to improve still further the lead response by operating the process at higher hydrogen absorption levels. Table 2 shows that this more severe treatment results in a gain of one number in the research octane number when leaded with 3.6 ml TEL/USG and also in a reduction in sensitivity of about one number.

TABLE 1—Normal Treatment—Typical Inspection and Stability Data on Raw Feed and Liquid Products

MATERIAL	Raw Feed[a]	Stabilizer Bottoms	Light Hydrotreated[a] Gasoline	Heavy Hydrotreated[a] Gasoline	Re-run Bottoms
Specific gravity @ 60° F/60° F.	0.7810	0.7805	0.7370	0.8350	0.931
Gravity, °API	49.7	49.8	60.5	38.0	20.5
Distillation, °F					
IBP	102	104	104	261	311
10 percent	138	140	126	269	358
30 percent	184	184	147	279	369
50 percent	227	223	168	286	376
70 percent	268	264	191	295	398
90 percent	321	317	221	315	435
FBP	378	381	255	338	507
Total sulphur, percent weight	0.020	.....	0.014	0.024	.....
Doctor test	Negative	.....	Negative	Negative	.....
Gum, mg/100 ml.					
Existent	21 (3)	.....	Trace	Trace	.....
Accelerated 120 min.	34 (18)	.....	Trace	Trace	.....
Accelerated 240 min.	118 (111)	.....	2 (2)	3 (2)	.....
ASTM induction period, min.	310	.....	685	680	.....
Bromine number	75.5	.....	82.5	23	.....
Flash point (PM closed), °F	.....	.....	.....	.....	148
Lauson Engine Test Ratings, mg/3.25 USG					
As received	280	.....	39	13	.....
After storage	280	.....	33	25	.....
Motor Octane					
Unleaded	79.3	79.0	77.0	82.6	.....
+ 3.6 ml TEL/USG	84.0	84.4	84.0	86.9	.....
Research Octane					
Unleaded	94.0	93.5	92.1	94.2	.....
+3.6 ml TEL/USG	98.3	98.4	98.6	99.0	.....
Hydrogen absorption, SCF/B	134				

NOTES: Gum values in ( ) obtained after n-heptane wash.
[a] Inhibited.

TABLE 2—Severe Treatment—Typical Inspection and Stability Data on Raw Feed and Hydrogenated Gasoline

MATERIAL	Feed[a]	Hydrogenated Gasoline[a]	Feed[a]	Hydrogenated Gasoline[a]
Specific gravity @ 60° F/60° F.	0.7830	0.7670	0.7790	0.7520
Gravity, °API	49.2	53.0	50.1	56.7
Distillation, °F				
IBP	104	107	104	108
10 percent	128	130	128	129
30 percent	153	151	149	150
50 percent	184	178	183	178
70 percent	227	212	238	215
90 percent	321	290	344	280
FBP	384	363	444	340
Gum, mg/100 ml.				
Existent	61 (13)	Trace	56 (26)	Trace
Accelerated 120 min.	105 (50)	1 (Trace)	93 (78)	Trace
Accelerated 240 min.	476 (445)	1 (1)	295 (288)	1 (Trace)
ASTM induction period, min.	200	>720	240	>720
Bromine number	66	48	74	46
Lauson Engine Test Ratings mg/3.25 USG				
As received	53	10	48	36
After storage	244	36	99	57
Motor Octane				
Unleaded	81.2	81.6	80.3	80.1
+ 3.6 ml TEL/USG	85.2	87.2	84.0	86.7
Research Octane				
Unleaded	96.5	95.0	95.6	94.3
+ 0.96 ml TEL/USG	98.2	98.2	97.7	97.7
+ 3.6 ml TEL/USG	99.6	100.8	99.4	100.4
H_2 absorption, SCF/B	180		198	

NOTES:
Gum values in ( ) obtained after n-heptane wash.
[a] Inhibited.

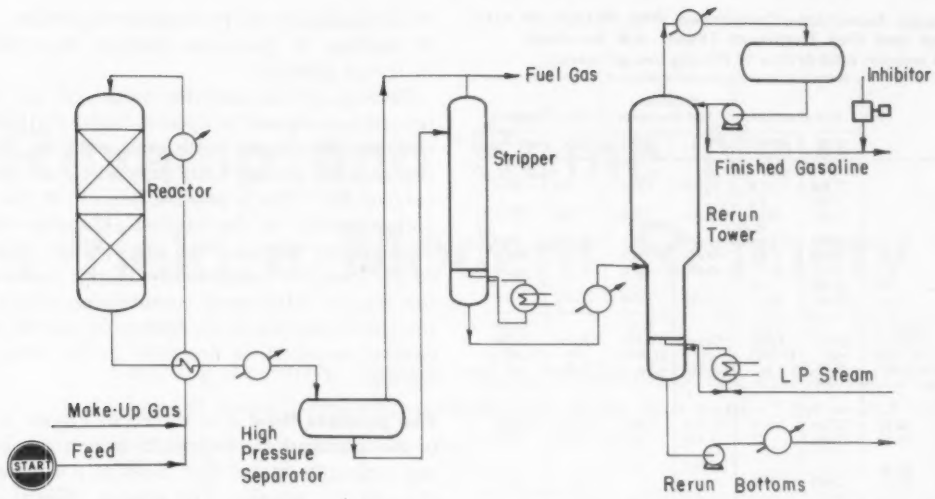

FIGURE 3—The process conditions are so mild as to produce no significant molecular breakdown or polymerization of the feedstock.

ECONOMICS OF THE PROCESS

The economics of the BP Selective Hydrogenation Process compare favorably with those of phosphoric acid treatment or clay treatment. The estimated overall refining costs for a 2,000 bpsd unit in a U.K. location are 50 cents per barrel of raw gasoline as compared with 99 cents for phosphoric acid treatment and 60 cents for clay treatment (Table 6). Caribbean prices for gasoline and fuel oil—with $4 per ton added to cover transportation to North West Europe—have been used in this estimate.[3]

The estimated investment cost of such a unit is given in Table 3 and operating cost in Table 4. The annual capital and operating costs are of the same order as for the other two polymerization processes (Table 5) but the much smaller degradation of gasoline to fuel oil in the BP process for equal product quality (3 percent weight on feed as compared with 17 percent for phosphoric acid treatment and 10 percent for clay treatment) makes the hydrogenation route the more attractive. No credit has been taken for any advantage in octane number that can be obtained by the BP process, nor have any direct charges, apart from extra labor, been made against clay treatment for disposing of the spent clay.

TABLE 3—Estimated Investment Cost of a 2,000 BPSD Unit

	Erected U.K. Basis, $
Process, materials	300,000
Process, erection	125,000
Civil engineering works (foundations, buildings & drains)	80,000
Design and engineering	95,000
Process unit erected in battery limits	600,000
Initial catalyst charge	7,000
Estimated total investment cost	607,000

TABLE 4—Costs of Utilities, Catalyst and Chemicals for a 2,000 BPSD Unit At a U.K. Location
(Basis: 330 operating days per annum)

UTILITIES	Per 1000 Bbl. Input: Consumption	Per 1000 Bbl. Input: Costs, $	Annual Costs, $
Steam			
450 psig steam @ $1.15 per 1000 lb	64,000 lb.	73.60	.....
180 psig steam @ $1.00 per 1000 lb	47,000 lb.	47.00	.....
Power, @ 1¢ per kwh	700 kw	7.00	.....
Cooling water, @ 1.5¢ per 1000 USG	380,000 U.S.G.	5.70	.....
Total utilities costs	.....	133.30	88,000
Catalyst	.....	.....	14,600
Inhibitor @ $1.4 per lb	20 lb.	28.00	18,200
Total utilities, catalyst and chemical costs	.....	.....	120,800

TABLE 5—Comparative Capital and Operating Costs With Phosphoric Acid Treatment and Clay Treatment
Basis: U.K. Location. Gasoline input: 2,000 BPSD or 77,400 long T/A of gasoline (Sp gr 60°F/60°F:0.75 or 57.2° API) 330 operating days per annum.

	Hydro-treating		Phosphoric Acid Treating		Clay Treating	
Capital Costs ($'000)						
(a) Process plant (excl. catalyst)	600		1,000		525	
(b) Offsites (excl. utilities)	200		200		200	
	800		1,200		725	
Annual Operating Costs ($'000/year)						
Depreciation						
10 percent on (a)	60		100		52	
5 percent on (b)	10	70	10	110	10	62
Operating Personnel						
8 plant operators @ $2,500/year	20		20		...	
10 plant operators @ $2,500/year	...		...		25	
Supervision	6	26	6	26	6	31
Maintenance						
4 percent on (a)	24		40		21	
¾ percent on (b)	2	26	2	42	2	23
Chemicals						
Process chemicals or catalyst	15		24		26	
Inhibitor in gasoline	18	33	15	39	16	42
Utilities		88		53		56
Overheads		40		50		45
Total operating costs, $1,000's/year		283		320		259
Cost per long ton input, $		3.66		4.13		3.35
Cost per bbl. input, $		0.43		0.48		0.39

FEATURES OF THE NEW HYDROGENATION PROCESS

High Product Quality. The process produces hydrogenated gasoline of excellent gum stability, high induction period and low Lauson engine manifold deposit rat-

TABLE 6—Process Economics—Comparison With Phosphoric Acid Treatment and Clay Treatment (Basis: U.K. Location)
(Plant capacity: 2,000 BPSD or 77,400 long tons per annum)

Material Balance	Hydrotreatment T/A	Hydrotreatment % Wt.	Phosphoric Acid Treatment T/A	Phosphoric Acid Treatment % Wt.	Clay Treatment T/A	Clay Treatment % Wt.
Input						
Pyrolysis Gasoline	77,400	100.0	77,400	100.0	77,400	100.0
Hydrogen Rich Gas	1,000	1.3	.....	.....	.....	.....
Total	78,400	101.3	77,400	100.0	77,400	100.0
Output						
Finished Gasoline	75,100	97.0	64,200	83.0	69,700	90.0
Re-run Bottoms	1,900	2.5	3,900	5.0	7,700	10.0
Sludge	.....	.....	9,300	12.0	.....	.....
Gas	1,400	1.8	.....	.....	.....	.....
Total	78,400	101.3	77,400	100.0	77,400	100.0

Product Realisation	Value of Product $/Long Ton	Quantity T/A	Total Value $1,000's/A	Quantity T/A	Total Value $1,000's/A	Quantity T/A	Total Value $1,000's/A
Credits							
Finished Gasoline	46.00	75,100	3,455	64,200	2,953	69,700	3,206
Re-run Bottoms	28.00	1,900	53	3,900	109	7,700	216
Sludge (Bunker 'C')	18.00	.....	.....	9,300	167	.....	.....
Gas (C_1-C_4)	20.70	1,400	29	.....	.....	.....	.....
Total	.....	.....	3,537	.....	3,229	.....	3,422
Debits							
Hydrogen Rich Gas	25.00	1,000	25	.....	.....	.....	.....
Operating Cost (table 5)	.....	.....	283	.....	320	.....	259
Total	.....	.....	308	.....	320	.....	259
Net Value of Products							
Total	.....	.....	3,229	.....	2,909	.....	3,163
Net Value of Products per Ton of Feed $/Long Ton			41.72		37.58		40.87
Value of Refined Gasoline $/Long Ton			46.00		46.00		46.00
Refining Cost							
$/Long Ton of Feed			4.28		8.42		5.13
$/bbl of Feed (8.54 bbl/ton)			0.50		0.99		0.60

ing. Marked improvement in odor also results from this treatment.

Selectivity. The catalyst is highly selective for hydrogenating gum forming compounds such as diolefins and styrenes and produces a stable gasoline without loss in leaded octane number.

High Yield. As expected, the process produces a high yield of hydrogenated gasoline of at least 97% weight.

Flexibility. The process is able to treat feedstocks produced from the pyrolysis of a variety of distillate feedstocks over a wide range of severities (typically from 12% to 25% weight ethylene on feed). Hydrogen streams of various sources and not of especially high purity e.g. catalytic reformer excess recycle gas or enriched steam cracker tail gas can be used in the process.

No Disposal Problems. The problem of disposing acid tar or spent clay is eliminated. Catalyst is of moderate cost and its life in commercial units exceeds six months.

Economic Advantages. The process has lower refining costs than phosphoric acid treatment or clay treatment owing to the much smaller degradation of gasoline to fuel oil.

HOW THE PROCESS WORKS

The process consists of the following steps:

- Catalytic reaction of raw gasoline with hydrogen
- Stabilization of hydrogenated gasoline
- Re-distillation of hydrogenated gasoline
- Addition of phenylene diamine anti-oxidant inhibitor to re-run gasoline.

Because of the unstable nature of the feedstock, the process is designed to operate under conditions which do not cause blockages in the equipment or rapid fouling of the catalyst charge with polymer which would shorten catalyst life. This is possible because of the high activity and selectivity of the catalyst. The reaction takes place at moderate pressure, low temperature and low gas rate which produce substantially liquid phase conditions in the reactor. Hydrogen consumption which depends on the characteristics of the feedstocks and the degree of upgrading required, is normally in the range 120 to 200 scf/bbl.

The process flow is as shown in Figure 3. The mixture of gasoline and gas rich in hydrogen is raised to operating temperature and then flows in a downward direction through the reactor. The reactor effluent is cooled and flash separated. The liquid product from the separator is then stripped of residual dissolved light hydrocarbons and finally re-distilled to a small residue.

For the purpose of blending in motor gasoline in certain refineries, it may be convenient to produce two distillates, a light and a heavy gasoline. The finished gasoline products are, after inhibitor addition, routed to storage, while the off-gases are usually disposed to fuel gas and the re-run bottoms to fuel oil.

The process conditions are so mild as to produce no significant molecular breakdown of polymerization of the feedstock. Yield losses result mainly from re-distilling the hydrogenated gasoline to a small residue make of 2 percent to 3 percent weight on feed.

The mild operating conditions make it possible to avoid the use of corrosion resistant alloy steels in the engineering design of the commercial gasoline hydrotreaters and all major items of equipment are fabricated of carbon steel.

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[3] Platt's Oilgram.

Key Words for Indexing

Costs, Cracking (chemical), Economics, Hydrogen, Hydrogenation, Investments

About the Author

Lester

R. Lester is a technologist for The British Petroleum Co. Ltd., London. Holder of a B.S. degree in chemical engineering from Manchester College of Technology, he joined BP in 1950. He has carried out experimental work on hydrotreating and hydrogenation processes at BP's research center, Sunbury, and has since 1959 worked as a specialist on these processes in the technical development division of the research center. During World War II, he did experimental work for the Ministry of Supply.

Big Revamp and Some New Units Yield a Modern Refinery

Century recently completed a modernization program which now gives it a well-balanced refinery. Here is a report on what this refiner is doing to keep up-to-date

M. D. Curran, Century Refining Co.
Garden City, Kansas

The Century Refining Company now has new facilities at its plant near Garden City, Kansas. The new units will permit Century to get improved quality and increased yields of higher-priced products. Rated at about 6,000 bpd, the revamped refinery has flexibility for greatest economy in product distribution. The plan used to delete obsolete equipment, add new equipment, and use existing equipment in the construction program is shown in Figure 1.

NEW FACILITIES IMPROVE PRODUCT QUALITY

A comparison of the old operation with operation achieved by the new facilities is shown in Table 1. Now Century can produce a high quality motor fuel having low sensitivity and seasonal control. This is possible because of the following unusual features of Century's small package type refinery:

- Propane deasphalting for quality asphalt and clean gas oil charge to the catalytic cracking unit.
- High conversion in catalytic cracking to make maximum gasoline yield.
- Superior quality of motor fuel containing alkylate.
- The adaptability of a small package type refinery to the limited marketing territory of Western Kansas and Eastern and Central Colorado.

WHAT CENTURY HAS NOW

The revamp and modernization scheme developed jointly by the Century Refining Company and Litwin Engineering Company of Wichita, Kansas is shown in Figure 2. The new propane deasphalting unit was designed by Curran Carbonizing and Engineering Company of St. Louis and was installed together with other off-site facilities by Century's own engineering and construction crew simultaneously with Litwin Engineering Company's construction of the following:

- New 3,000-bpd Socony Mobil Airlift TCC unit
- New gas concentration plant
- New 800-bpd Phillips HF alkylation unit

The existing crude and vacuum units. These include standard pipe still design with atmospheric and vacuum fractionation. While little or no changes were required in these units to process 6,000 bpd, the high wax content in Panhandle Eastern's paraffin base crude made it impossible to meet the rigid asphalt specifications without first extracting these waxes from the vacuum still bottoms.

In solving this wax problem, Curran Carbonizing and Engineering Company conducted an extensive study of other asphalt plant operations and incorporated in its design of a new propane deasphalting unit all the best features of other plants for making a wide range of high quality asphalt products. While the market demand required essentially 85-100 penetration grade asphalt, the

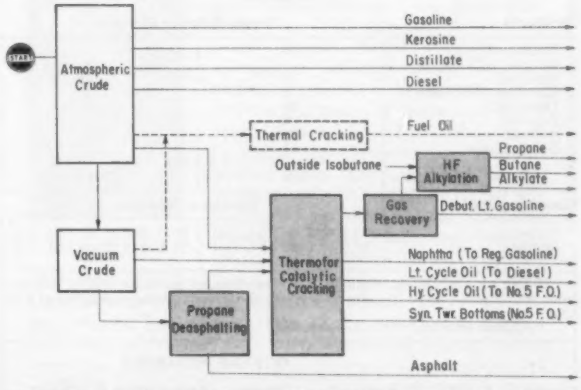


FIGURE 1—A catalytic cracking unit replaces the thermal cracking unit of the old operation. This diagram shows in color the other new units which were added.

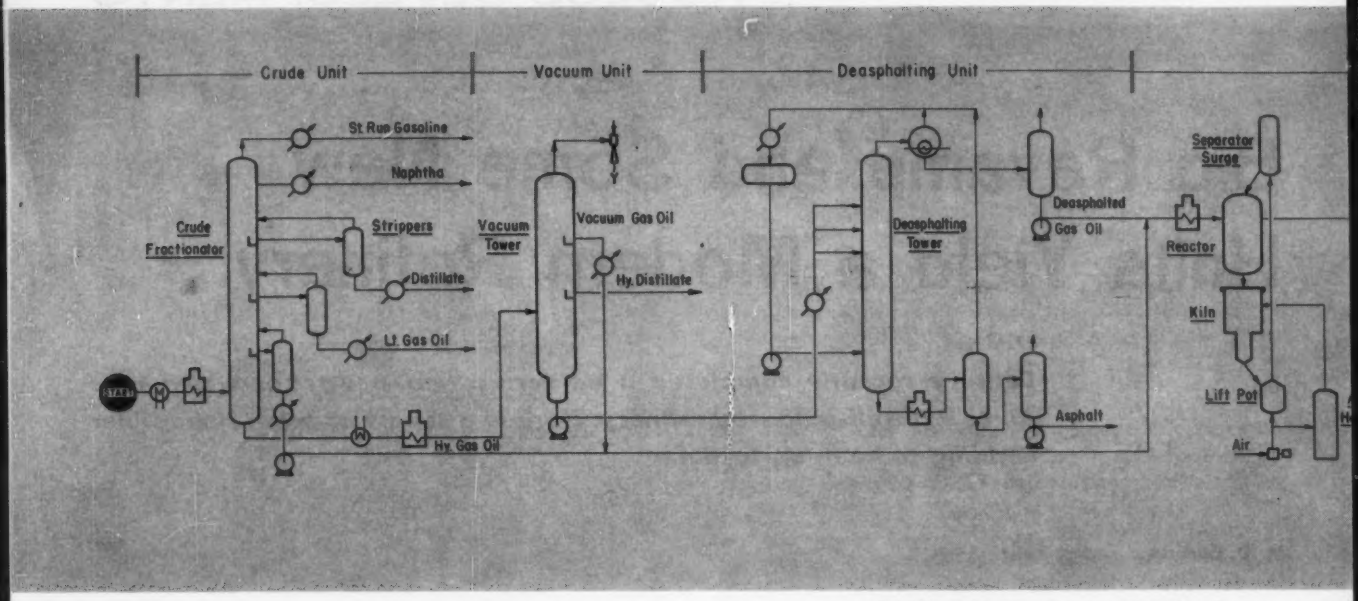


FIGURE 2—The Century Refining Company now h

new unit readily produces the other blending stocks necessary for production of the many grades of road asphalts required for the local market.

The clean low metal content gas oil produced from the propane deasphalting unit makes an excellent charge stock for the cat cracker.

The Airlift Thermofor Catalytic Unit. This unit replaces thermal cracking of the old operation. The Airlift TCC unit was selected on account of the flexibility of the process, and the wide range of feed stocks that could be charged to the unit for making high yield of high octane gasoline. In Century's operation the maximum economy is attained by operating for maximum gasoline yield with minimum fuel production; and in the same operation produce a high ratio of isobutane to butenes for charge to the alkylation unit.

Because of the limited market for industrial fuel and burning oil, the TCC unit is operated at very high gasoline production. Satisfactory results have been attained at 100 percent conversion. In present operation the unit is purring along at 95 percent conversion with low production of light cycle oil and no bottoms.

The 90 percent @ 385° F gasoline stream constantly runs at 98 F-1 octane with 3cc TEL/Gal. In this nonresid operation only gasoline, alkylate, light cycle oil, LPG, and dry gas are produced. The constant ratio of isobutane to butenes has been a great operating advantage in holding the proper plant balance for alkylate feed stock.

The easy-to-start-up and keep-on-stream features accomplished by automation of this unit assist in Century's most modern operations.

TABLE 1—How New Facilities Change Product Distribution and Quality

Products	Old Operation[1]	New Operation[2]
	Yield, Volume Percent	
Propane	...	1
Butane	...	...
Gasoline	39	59
Kerosine (Distillate)	5	6
Diesel Oil	20	13
Fuel Oil	4	...
Asphalt	21	17
Gas & Losses	11	4
Total	100	100
Gasoline Grades	**Research Octanes**	
Premium	93.0 @ 3 cc TEL/Gal	99.0 @ 2.76 cc TEL/Gal
Regular	87.0 @ 3 cc TEL/Gal	91.6 @ 2.68 cc TEL/Gal

[1] During the old operation it was necessary to purchase 8% of alkylate from an outside source in order to produce the gasoline being marketed at that time.

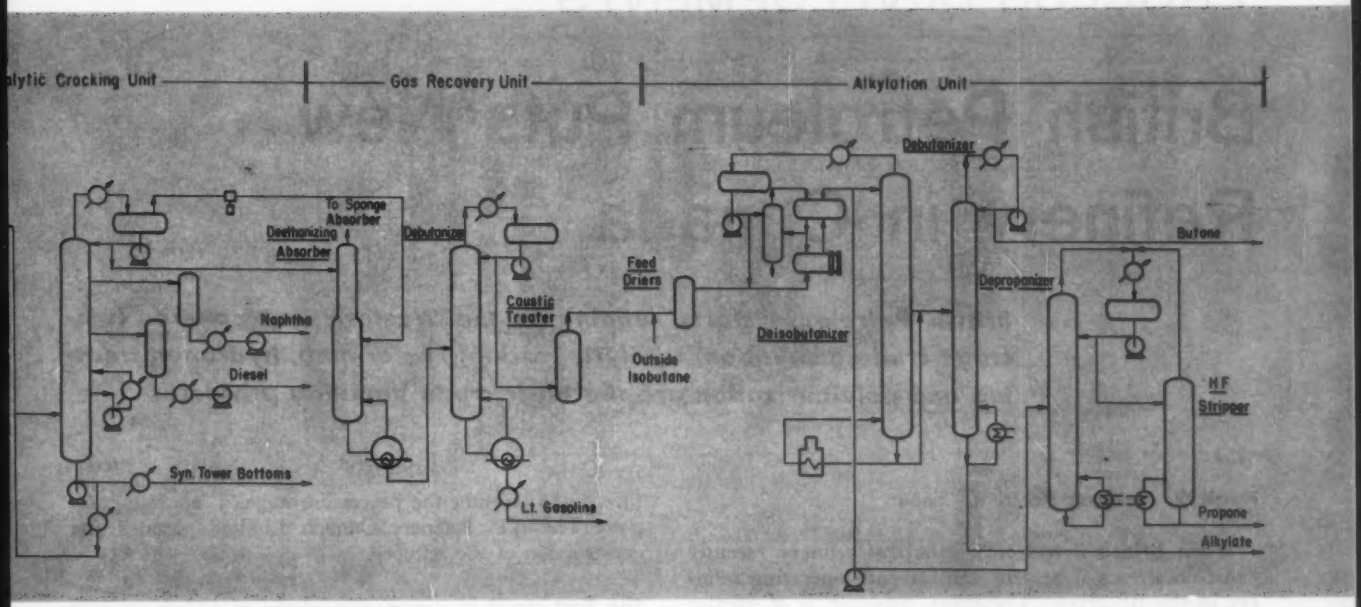
[2] Typical tests of present gasoline are:

Grades	OCTANE NUMBERS			
	Research	Motor	Sensitivity	Road
Premium	99.0	96.4	2.6	99.5
Regular	91.6	86.0	5.6	91.8

The Gas Concentration Plant. This plant as shown on process flow sheet serves as a mulit-purpose unit. It separates the dry gas to fuel, the C_3-C_4 fraction to alkylate feed and debutanized gasoline to base stock.

HF Alkylation. The new 800 barrels per day Phillips Alkylation Unit was designed to convert propylene, butylene, and isobutane into the highest quality motor fuel alkylate. The feed for this unit is produced by the crude unit, the TCC unit and isobutane purchased from nearby suppliers.

As sown in the process flow sheet, the fresh feed streams are pumped through the desiccant driers to remove water that may be picked up in processing. The dry liquid feed passes to the new type reactor-settler where high octane alkylate is produced. The separation of the products formed in the reactor-settler is accomplished by pumping the total charge to the fractionator where propane of LPG grade, alkylate, and recycle iso-



w facilities at its plant near Garden City, Kansas.

butane are separated. All butane production is retained in product streams for vapor pressure control.

The unit is designed for a C_4 charge to produce 107.5 Research octane number with 3cc TEL/Gal. In present operation with C_3-C_4 charge, the Research octane number consistently runs from 104 to 105 with 3cc TEL/Gal. The present acid consumption is about 0.2 pound per barrel.

HOW CENTURY REFINING GREW

The first Century Refining Company was organized in 1937 at the present location. The plan was to process low gravity high asphalt crude that had limited market. The project was encouraged by the Atlantic Refining Company which was the principal producer of the heavy crude oil in the western Kansas area.

The demand for the products from this little refinery was not great. The market soon became saturated making it possible to operate the units only intermittently, starting up and shutting down many times.

Later in an effort for continued operation, a small thermal cracking unit was added. This part of the refinery can easily claim historical importance to the refining industry. It included a pilot plant that was previously used in establishing the validity of certain phases of the thermal cracking patents. The small unit was salvaged from junk, moved to the Garden City plant and there installed to crack the vacuum gas oil. Although this improved operation was followed with a bauxite reformer and desulfurized, it still failed to produce octanes to meet market demand. The high gas loss in this operation made it uneconomical to continue operations, resulting in shutting down the refinery indefinitely.

Now the "new" Century Refining Company is a relatively different company. It was formed in 1956 as a subsidiary of Panhandle Eastern Pipe Line Company to establish a refining and marketing division. The addition of this Century division not only makes Panhandle Eastern Pipe Line Company a more integrated company; but it provides a substantial market for its western Kansas crude and natural gas products.

After completing its organization, the new Century Refining Company purchased the then existing Century refinery located a few miles north of Garden City, Kansas. This plant then was the starter for the new revamped and modernization described here.

Key Words for Indexing

Alkylation, Construction, Cracking (Chemical), Decarbonizing, Design, Distillation, Refineries

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About the Author

Curran

M. D. Curran is president of Century Refining Company. Mr. Curran graduated from the Ohio State University in 1914 with an engineer of mines degree. Since then he has worked for Republic Steel Co., was assistant general superintendent for Toledo Furnace Co., president of St. Louis Coke and Iron Corp., and executive vice-president of Missouri Kansas Pipe Line Co. After the depression, Mr. Curran organized the Radiant Fuel Co. and the Midwest Smokeless Fuel Corp. to produce smokeless fuel from Illinois coal. He also organized the Curran Carbonizing and Engineering Company to build and sell coking plants. At one time he assisted the Peruvian government in opening of anthracite coal mines and has been employed during recent years by various foreign governments as consultant of coal and steel production. In 1958, he undertook a study of the operations of Century Refining which led to the revamp work reported here.

British Petroleum Puts New Refinery in Canada

British Petroleum starts refining in the Western Hemisphere. Two-stage crude distillation, catalytic cracking, reforming, hydrogen treating and polymerization are the basic crude handling processes

Hugh G. Jarman, Montreal, Canada

When British Petroleum's Montreal refinery recently came on stream it became the fifteenth operating refinery in the BP group. The event, however, is of greater significance than just an increase in BP's refining capacity. It marks the opening of BP's refining activities in the Western Hemisphere.

The process units for the new refinery were selected to produce a high yield of gasoline in the high to regular octane range, diesel fuel, heating oil, furnace oil, heavy fuel oil and propane. These units are as follows:

- Atmospheric and Vacuum Crude Distillation ..... 25,000 bpsd
- Catalytic Cracking ..... 9,000 bpsd
- Catalytic Reforming ..... 6,000 bpsd
- Distillate Hydrotreating ..... 12,000 bpsd
- Polymerization ..... 800 bpsd
- Also Copper Chloride and Inhibitor Sweetening

THE REFINERY TAKES SHAPE

A marketing company, BP Canada Ltd., was first formed in 1957 after an extensive market survey. When time came to enter the processing stage, a separate company The B.P. Refinery Canada Limited planned the construction of the refinery.

The first stage of construction, designed and engineered by BP, provided handling and storage facilities before the processing units came into being. The first stage included a 3½-mile products pipe line from the refinery site to the transit site and wharf on the St. Lawrence River, firefighting and drainage facilities were also installed at this time.

The processing units were engineered by the Lummus Co. Ltd., and was implemented by joint effort of BP Refinery Canada Ltd., Lummus Co. Canada Ltd., Montreal, B.P. Trading Ltd. and Lummus Ltd. of London England. The reactor sections and reforming units as well as the catalytic polymerization unit were designed and engineered by the Universal Oil Products Co.

The peak labor force engaged on the construction of the refinery was 2,400; and 80 percent of the entire refinery cost was spent in Canada. The plant covers a 600-acre site 10 miles east of the city of Montreal.

The Montreal refinery is a highly intergrated plant, in which individual units are very closely associated. Al-

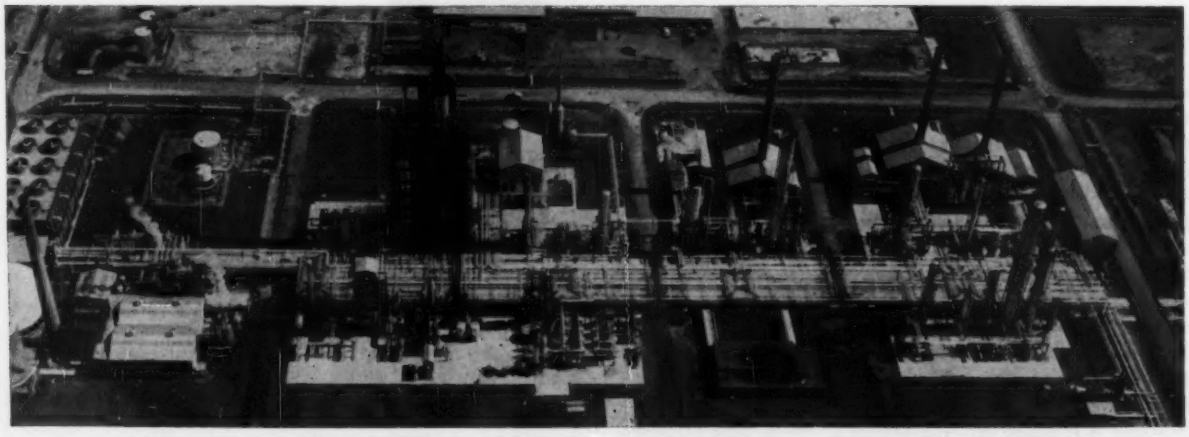


FIGURE 1—The general layout for maintenance is based upon the extensive use of mobile equipment.

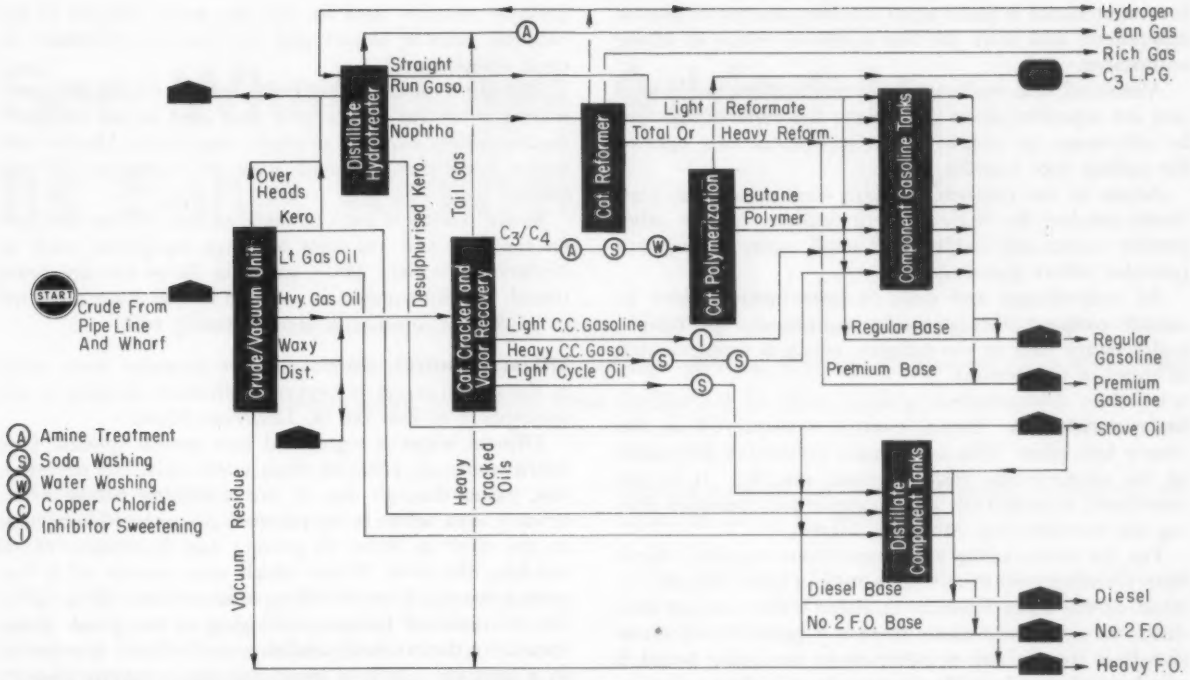


FIGURE 2—The process units for the new refinery were selected to produce a high yield of gasoline in the high to regular octane range, diesel fuel, heating oil, furnace oil, heavy fuel oil and propane.

though the entire operation is supervised from a central control room, the units can be operated in three separate groups:

- Crude and vacuum unit.
- Hydrotreater and catalytic reformer, with associated distillation trains.
- Catalytic cracker, vapor recovery unit, catalytic polymerization unit, and associated treaters.

Economy has been achieved through the minimum use of energy with provisions for short stream runs, and direct feed from one process to another, thus reducing the usual cooling and reheating several process streams. The design provided the required amount of intermediate storage tankage to allow for operating fluctuation.

ABOUT THE PROCESS DESIGN

The basic crude feedstock considered in setting the design of the refinery was Qatar crude. However, the design is flexible enough to accommodate other crudes satisfactorily. It is estimated that, in 1961, 4,402,000 barrels of Qatar crude. (42 API gravity) and 3,210,000 barrels of T.N.A. Trinidad crude (31 API gravity) will be processed.

The liquid product separated from the crude units is fractionated in a distillation train to provide Platformer feedstock, kerosine, and other products. The system allows the refinery to produce a closely-controlled range of light distillates.

The Platformer incorporates the latest improvements in construction and catalyst specifications, and the reaction train can produce 100 research octane reformate as the normal condition. Provision is made to regenerate catalyst in the unit.

The catalytic cracking unit is of standard design, with reactor and regenerator stacked. Catalyst is recirculated at about 1000 tons per hour, and coke can be burned at 5-tons per hour.

The catalytic polymerization unit is of the single chamber type. Feedstock is amine treated to remove hydrogen sulphide, washed with dilute and concentrated caustic soda, to remove H_2S traces and other sulphur compounds, and finally water-washed before going to the polymerization unit.

Gasoline streams from the catalytic cracking unit are suitably treated, the heavy stream in a slurry type copper chloride unit, and the light stream in the inhibitor sweetening facilities. Necessary provision is made for caustic washing.

Pipe Rack. The central feature is the overhead pipe rack, alongside which the main units are arranged. The pipe rack is constructed entirely of precast concrete, and designed as a rigid frame structure. The design is both economical in first costs, and has the advantage of being fireproof.

The space under the pipe rack is partly used to house the various pumps. This arrangement provides very economical short pipe runs and provides protection for the pumps, eliminating separate pump houses. In Montreal the weather demands a certain amount of pump covering. Where this was necessary concrete slabs were erected for walls and roof.

Maintenance simplified. In achieving the very compact design of the processing area, care was taken to provide ample space for maintenance. The general layout

for maintenance is based upon the extensive use of mobile equipment, and there are few overhead beams or lifting equipment.

Almost all heat exchangers are mounted on grade level and are separated from the heaters and other equipment by alley-ways in which mobile equipment can operate for pulling tube bundles, etc.

Access to the catalytic cracking unit consists of platforms reached by stairways or ladders, on the other process towers only ladders and small access gratings are provided where necessary.

All maintenance and work on instruments is done by outside contract, the contractor maintains a permanent maintenance staff at the refinery, which is supplemented at times of turnaround.

Instrumentation. Instant control is required in this closely knit plant. This is the main reason for the choice of the all-electronic control system installed. It is also considered economically advantageous for operation during the extreme cold Montreal winters.

For the instruments, local regulations required aluminum sheathed multicored cable runs in open troughs, instead of the more familiar insulated cable runs in conduits. In some areas where there is a possibility of excessive heat from a fire or other cause insulating board is run beneath or alongside the trough, this electronic control was even extended to the boiler room.

Except for smaller sizes, control valves are not provided with bypasses, and are of the conventional air-operated type.

Heaters. The crude heater is of standard type and is combined in the same housing as the vacuum column heater. A combination heater is used with the Platformer, succeeding stages of the process stream passing through different sections within the main heater housing. The reactors are arranged in a bank close to the heater. The heater for desulphurizing occupies a common housing with the direct-heat reboilers for the distillation train in which the reactor liquid product is separated into Platformer feedstock, kerosine, and so on.

The heaters are equipped with combination gas and oil burners, and are provided with 150-foot exhaust chimneys.

Steam. Two 90,000 pound-per-hour boilers provide all of the necessary steam at 650 psig and 800° F. This is used in the refinery at 600, 150, and 50 psig. The high pressure steam is used for the two main turbines at the catalytic cracker blower and the catalytic reformer recycle compressor.

In addition to the steam being used in the various processes and motive power it is also used on an extensive tracing system required in winter operations. Most of this system is 50 psig, although some of it requires 150-psig steam.

Steam tracing is used on some of the process lines and on the fuel and gas lines to plant equipment such as heaters and boilers. Many valves in the system are steam traced, and instruments in exposed locations are mounted in enclosures fitted with steam heating coils.

Effluent Control. Several positive measures were taken in the design stages to prevent pollutants escaping to the atmosphere or into the St. Lawrence River.

Effluent water is segregated into several systems. One system normally contains clean water only, but nevertheless, passes through one of two skimming ponds in the refinery area before being pumped down the effluent pipe to the river in order to prevent any breakaway of oil reaching the river. Water which may contain oil is first passed through a set of API separators where oil or sludge can be removed before discharging to the pond. Spent soda from the cracked gasoline caustic washer is collected in a tank for sale to a local chemical company who recovers phenols from it.

All product tanks which contain crude or light oils have been designed to withstand 4 inches of water pressure and are fitted with pressure-vacuum vents which reduce the amount of light hydrocarbons lost to the atmosphere due to tank movement or "breathing." Foul gases produced in the refinery are burnt in furnaces, e.g., vapor from the vacuum overhead system and from the caustic regenerator on the polymerization unit.

Safety valves which could pass H_2S are connected to the flare system. Chimneys are high enough to allow gases to disperse. The refinery flare is 150 feet above the ground and was designed to burn with a smokeless flame.

Tank Farm. Normal provisions are made for storing crude and products. Because of the intergrated design of the refinery, the intermediate tankage is reduced to a minimum for buffering between the groups when the units are started up.

The tank farm is designed for separate storage of certain basic products that can be blended in a line-blending system. This allows flexibility in the choice of by-products to meet seasonal demands.

Heated storage tanks are insulated, as a more economical method than providing additional steam facilities. Tank mixers have been installed in the crude tanks.

Montreal's cold winters prevent the construction of the usual floating roof tanks. The volatile products tankage, of the fixed roof type, have been constructed with certain fittings so that vapor-retaining blankets can be added if required without welding or other heated work. The blankets are made of plastic material in sections that can be readily joined together inside the tanks.

The capacity of this tank farm is over 1 million barrels.

Jarman

About the Author

Hugh G. Jarman is a mechanical engineer. A member of the Society of Automotive Engineers, he received his education at the University of Illinois. His past experience includes work in the engineering departments of Ford Motor Co. and Hudson Motor in Detroit.

Key Words

Canada Construction Design Refineries

See What Brazil Added to Its Bahia Refinery

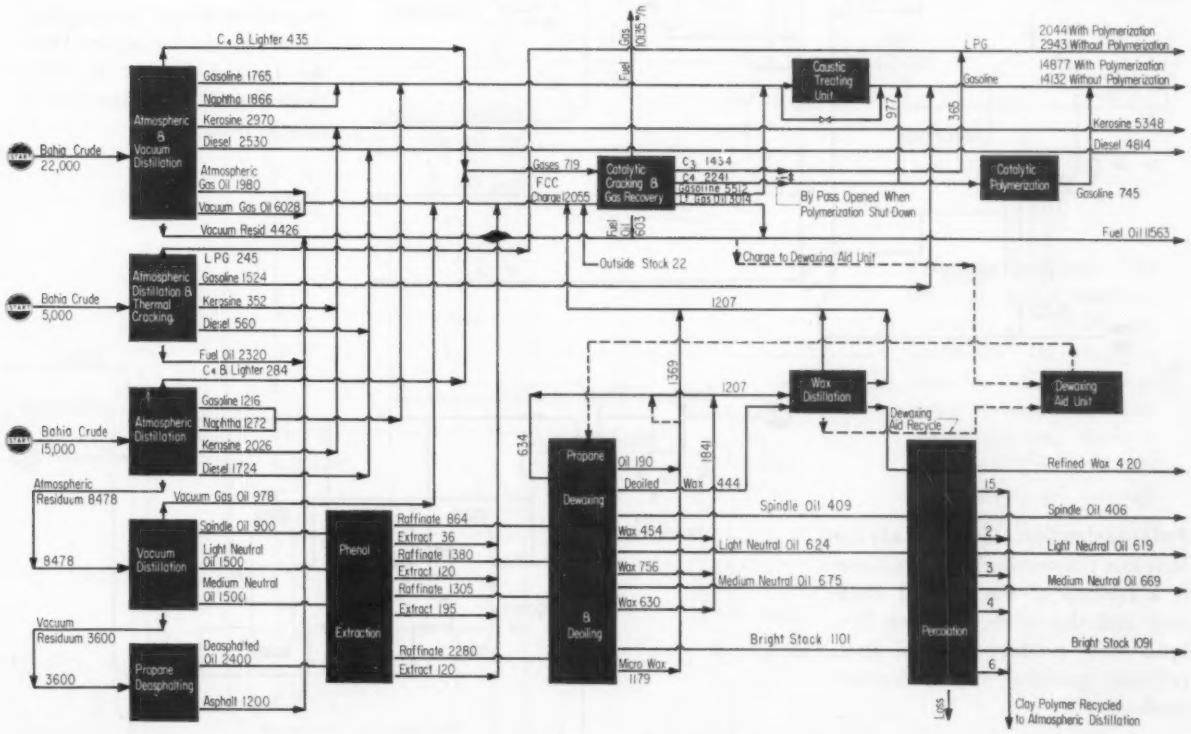
These new processing units will up Petroleo Brasileiro's crude handling capacity at its Landulpho Alves, Bahia, Refinery. See the type of processing facilities now included in this newly expanded refinery

J. A. Davies Freitas
Petrobras-Petroleo Brasileiro, S.A.
Rio de Janeiro, Brazil

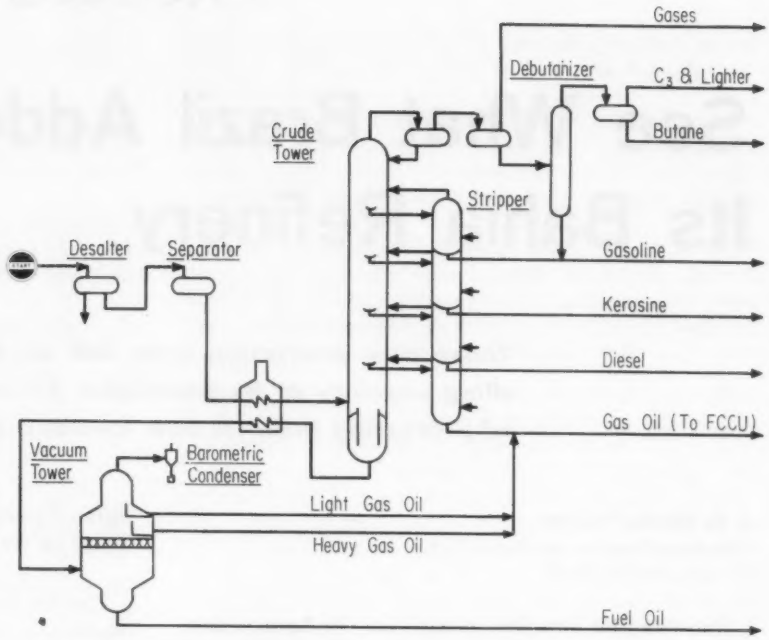
Petrobrás, the Brazilian government Oil Agency, completes one more step in its program for Brazil's self-sufficiency in oil. The Landulpho Alves refinery, formerly Mataripe refinery, in the State of Bahia, underwent a complete expansion program that will make runs jump from 9,000 bpsd to 42,000 bpsd and later on to 52,000 bpsd. New units include a new 22,000 bpsd atmospheric and vacuum distillation, a new polymerization unit, a model B Orthoflow catalytic cracking unit, and an integrated complex for lubes and waxes production, designed by the M. W. Kellogg Co.

The first unit in Mataripe went on stream in 1950 and consisted of a 2,500 bpsd combination unit designed by the M. W. Kellogg Co. to process the scarce crude production then attained from Bahia fields. With the crude output increase, a new unit, similar to the first one, was put on stream by 1953. Also completed by then, a small 180 bpsd catalytic polymerization unit went on operation.

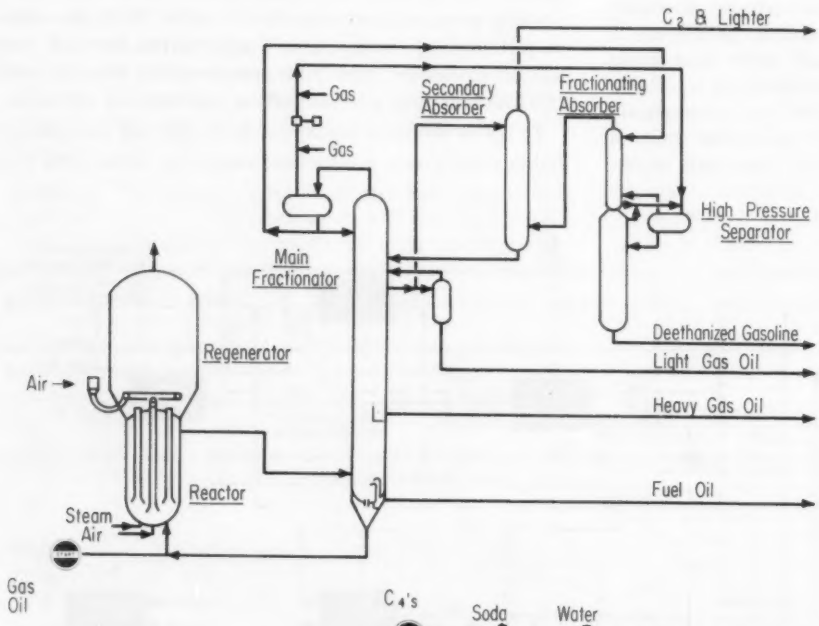
In 1950 the most optimistic forecasts did not predict Bahia waxy crude production would rise from 1,000 bpd



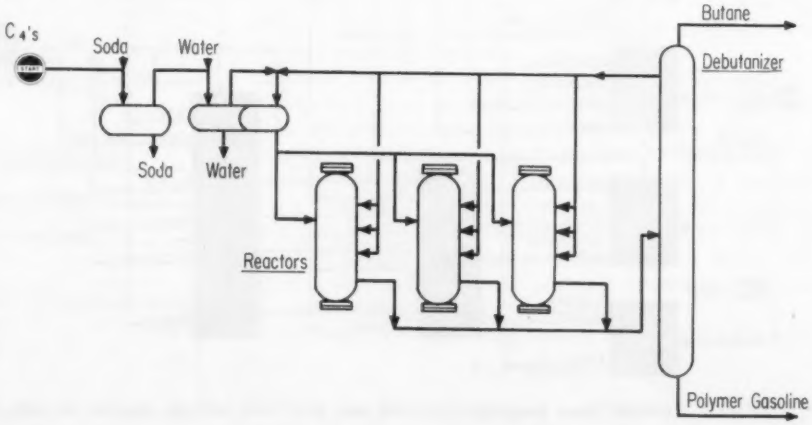
Overall Flow Diagram. How old and new units will tie together to make Brazil's petroleum products.



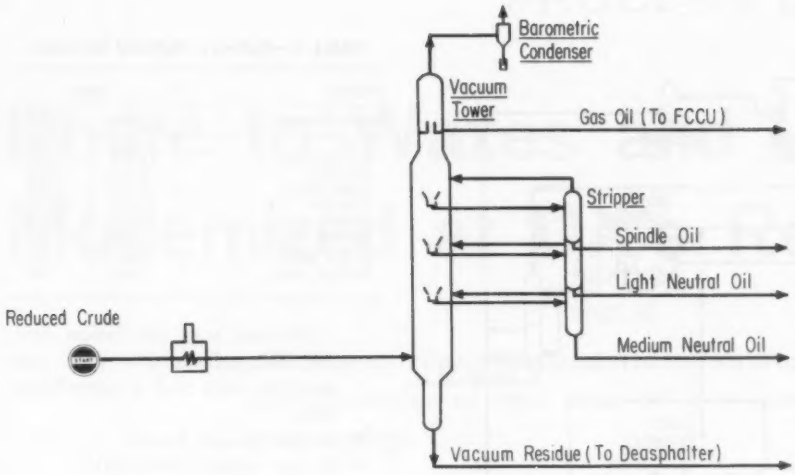
Two-Stage Crude. The new 22,000 bpsd atmospheric and vacuum crude distillation unit is designed to handle imported Kuwait oil in addition to waxy Bahia crude.



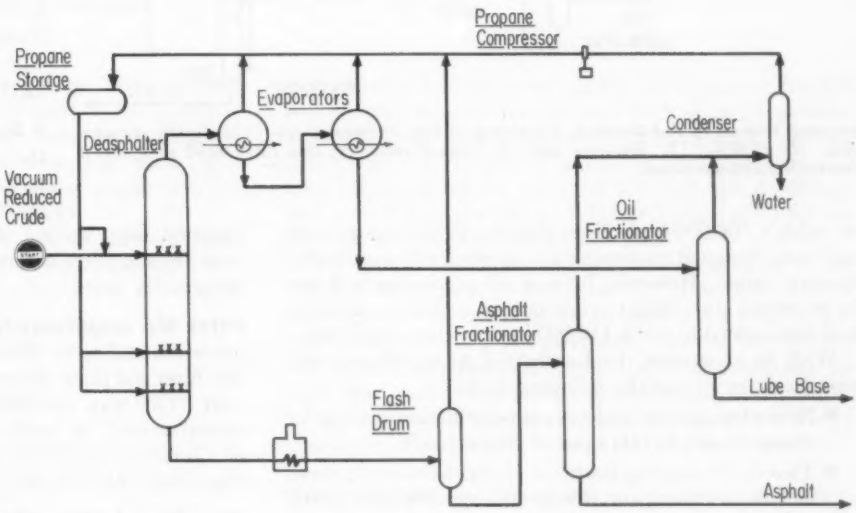
Catalytic Cracking. In addition to the towers shown here, the model B Orthoflow unit includes debutanizer and depropanizer towers for handling the deethanized gasoline. Then the liquid C_3 cut is DEA treated and the gasoline is caustic treated.



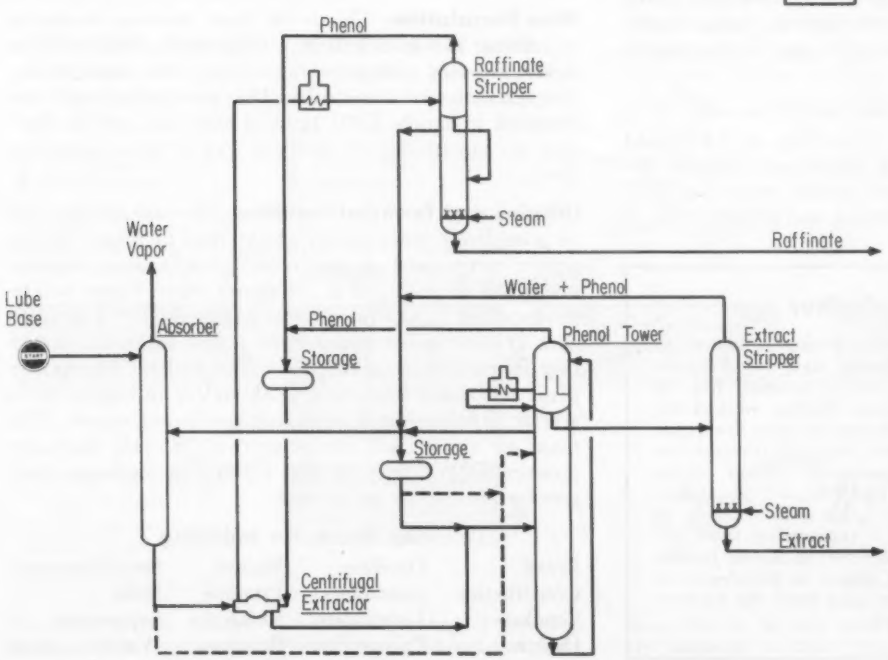
Polymerization. Two catalytic butylene polymerization units—one is a revamp of the old 181 bpsd unit and the other is a new 514 bpsd unit—produce a 5 psi Rvp polymer gasoline and a butane product.



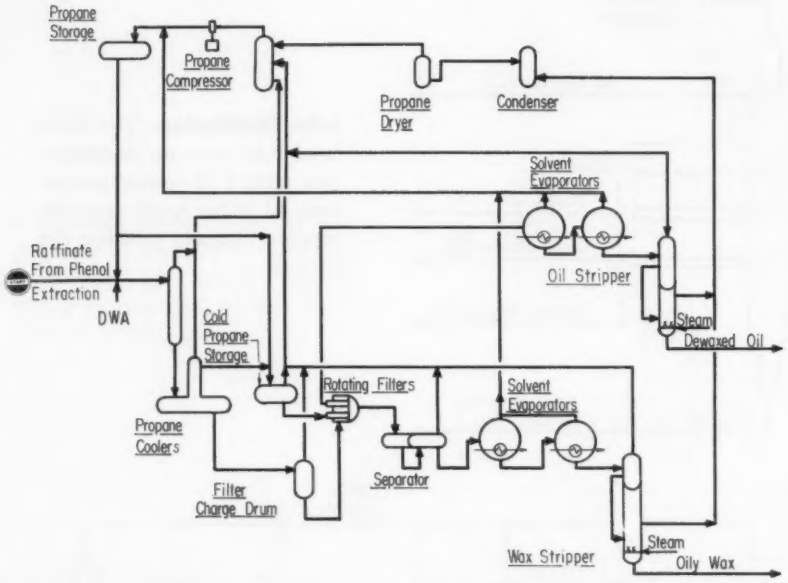
Lube Distillation. The 9,978 bpsd lube vacuum distillation unit takes a 56 volume percent reduced Bahia crude from the topping unit and produces five streams.



Propane Deasphalting. Using a propane to oil ratio of eight to one, this unit will handle 3,600 bpsd of vacuum residue to make 2,400 bpsd of deasphalting oil for bright stock recovery.



Phenol Treating. The phenol extraction unit operated on blocked out operation. Its charging capacity is 6,000 bpsd or more, depending upon the charge stock. Refer to the over-all refinery flow diagram to see average quantities of the charges handled.



Propane Dewaxing and Deoiling. Consisting of four essential steps: (1) solution preparation, (2) chilling, (3) filtration and (4) solvent recovery; this 7,211 bpsd unit also is run on blocked operation.

TABLE 1—Refinery Material Balances

ITEMS	bpsd	
Crude Charge	42,000	52,000
LPG	2,044	2,083
Gasoline	14,877	15,841
Kerosine	5,348	7,022
Diesel Oil	4,814	5,978
Fuel Oil	11,563	17,721
Spindle	406	406
Light Neutral	619	619
Medium Neutral	669	669
Bright Stock	1,091	1,091
Refined waxes	420	420

to today's 100,000 bpd. Even the new 22,000-bpsd crude unit was designed to process also foreign oil, specifically Kuwait crude. However, foreign oil processing will not be necessary since Bahia crude output is rising constantly and is estimated to reach 110,000 bpsd by the end of 1961.

With its expansion, the Landulpho Alves refinery will now have on stream the following units:

- New atmospheric and vacuum distillation unit to be charged with 22,000 bpsd of Bahia crude.
- Two crude topping units for 15,000 bpsd each; these will be a revamp of the present combination units, and will also be charged with domestic Bahia crude.
- A new 12,000 bpsd (fresh feed) model B Orthoflow unit.
- A new 514-bpsd catalytic polymerization unit.
- An integrated lube plant comprising an 8,500-bpsd vacuum distillation unit, a 3,600-bpsd propane deasphalting unit, a 6,300-bpsd phenol extraction unit, a 7,200-bpsd propane dewaxing and deoiling unit, a 1,900-bpsd wax distillation unit, 730,000 gallons per year wax modifier unit and a percolation unit.
- A new power house.
- A new marine terminal.

The product distribution for the newly expanded refinery is given in Table 1 along with the distribution which is expected for a new target of 52,000 bpsd.

A Story in Flow Diagrams. Most of the units included in the expanded refinery are depicted in the flow diagrams accompanying this article. Omitted from among these diagrams, however, are the ones for the filter aid manufacturing plant and the wax percolation unit.

Filter aid requirements for the propane dewaxing unit are estimated to be around 470,000 gallons per year, but the filter aid plant design capacity is 730,000 gallons per year. The wax modifier or filter aid solution will be manufactured in batch operations by chemical reaction of a finished 130-132° F melting point wax, with chlorine, aluminum chloride and naphthalene.

Wax Percolation. This is the final finishing treatment in refining of waxes and lube base stocks. Bauxite-filled towers are used to improve odor, taste, color and stability characteristics of the stocks. The percolation unit was designed to handle 2,801 bpsd of lube oils, and 60 short tons per stream day of distillate wax or microcrystalline wax.

Utilities and Terminal Facilities. The new refinery will be completely independent of external facilities. Steam, power, compressed air, and other plant facilities requirements will be produced in the power plant. Steam will be produced at approximately 600 psig and 750° F in three new 225,000 lbs/hr steam boilers, and saturated at 175 psig in three existing 37,500 lbs/hr boilers. The power plant will have three new 2,500 KVA turbogenerators and an existing diesel generator, for power supply. The plant air system will comprise two 100 psig discharge pressure air compressors, and a 100 psig discharge pressure instrument air compressor.

About the Author

Freitas

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Key Words for Indexing

Brazil, Construction, Crackers, Design, Deoiling, Extractors, Lubricants, Polymerizers, Phenol, Propane, Refineries, Reactors, South America, Stills, Separators, Waxes ##

Route to Waxes and Lubes Modernized at DX's Refinery

DX Sunray continues modernization steps at their Tulsa refinery. Here is a discussion of their over-all plan and a report on how each step is progressing

G. F. Adams, F. T. Mertens and R. L. Godino
DX Sunray Oil Co., Tulsa

Fewer and more efficient units requiring lower utilities, manpower and maintenance are all part of the justification of DX Sunray Oil Company's new lubricating oil and wax processes in its Tulsa refinery. The more modern facilities permit better yields of better products without changing the original charge stocks.

Although the processes are part of an over-all plan, each unit is economically justified on an individual basis. The units which are part of this project are as follows:

- **Three-stage crude distillation**
- **Two-stage propane deasphalting**
- **Solvent extraction**
- **Solvent dewaxing and deoiling**

The order in which the modernization steps are being made is shown in Figure 1. Each of these steps will be discussed in the following sections.

SOLVENT DEWAXING AND DEOILING UNIT

Economics dictated that the solvent dewaxing and wax deoiling unit should be the first to be constructed. Accordingly, DX prepared design specifications for this unit so that it could be operated both with the remaining existing equipment and also in the ultimate modernized processing system. Competitive bids for this unit were taken during the winter of 1958-59, and a contract was awarded to the Foster Wheeler Corporation for the construction of a MEK-Toluol Unit.

The MEK-Toluol process was chosen because of attractive investment and operating costs and because experience of other refiners had shown the process was capable of producing low pour point oils and low oil content waxes simultaneously. DX felt that demands for high wax purity would become increasingly important in the future and placed severe requirements on the oil content of the finished waxes from the new unit.

The stringent specifications necessitated the use of concurrent two stage wax deoiling. In this operation the primary slack wax obtained during solvent dewaxing of the waxy charge stocks is recrystallized in the presence of solvent to remove essentially all of the oil and soft

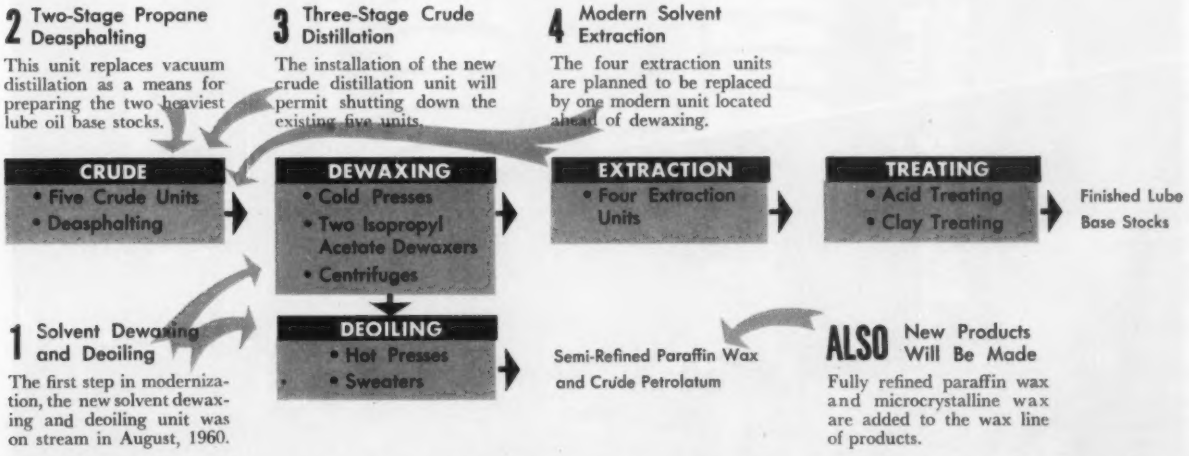

2 Two-Stage Propane Deasphalting
This unit replaces vacuum distillation as a means for preparing the two heaviest lube oil base stocks.
3 Three-Stage Crude Distillation
The installation of the new crude distillation unit will permit shutting down the existing five units.
4 Modern Solvent Extraction
The four extraction units are planned to be replaced by one modern unit located ahead of dewaxing.
CRUDE
• Five Crude Units
• Deasphalting
DEWAXING
• Cold Presses
• Two Isopropyl Acetate Dewaxers
• Centrifuges
EXTRACTION
• Four Extraction Units
TREATING
• Acid Treating
• Clay Treating
Finished Lube Base Stocks
DEOILING
• Hot Presses
• Sweaters
Semi-Refined Paraffin Wax and Crude Petrolatum
1 Solvent Dewaxing and Deoiling
The first step in modernization, the new solvent dewaxing and deoiling unit was on stream in August, 1960.
ALSO New Products Will Be Made
Fully refined paraffin wax and microcrystalline wax are added to the wax line of products.

FIGURE 1—DX Sunray is now inaugurating a four-step modernization program for their lubricating oil and wax processes. This is the way their processing will be altered to add new materials to their line of finished products.

waxes not wanted in the finished product. The recrystallized wax cake is repulped with fresh solvent in a special heating and chilling step, and the oil content is reduced to a practical minimum.

The new solvent dewaxing and deoiling unit, placed on stream in August 1960 is one of the largest units of its kind. A flow diagram for the unit is shown in Figure 2.

The unit requires the circulation and recovery of 40,000-45,000 bpd of solvent mix, in order to successfully process the ten different feed stocks. These oils, varying from a distillate of 65 SUS viscosity @ 100° F to a deasphalted bright stock, must be charged to the unit at rates ranging from 6,000 bpd to 11,000 bpd.

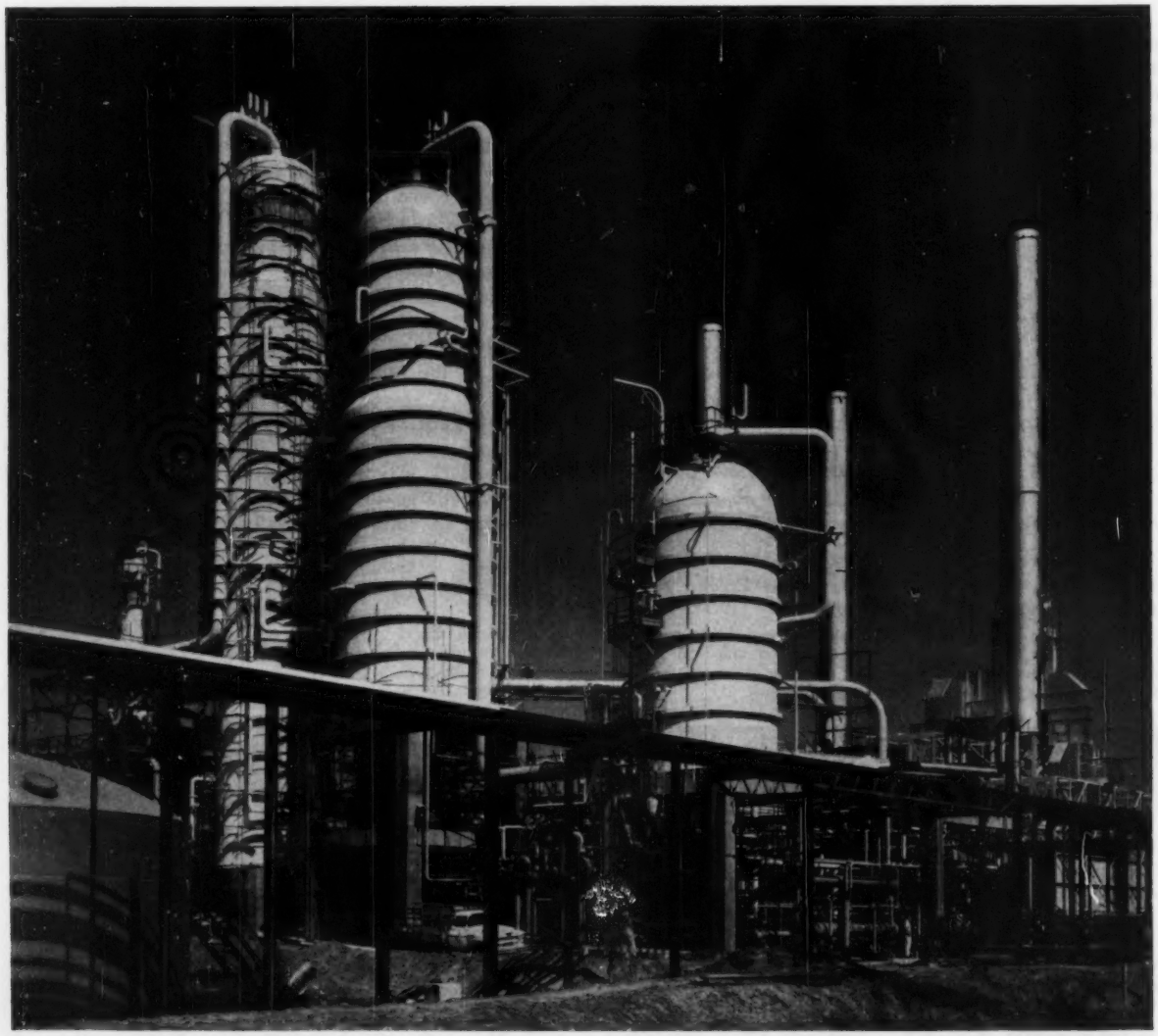
Optimum operating conditions had to be established for each of the oils. Dilution solvent ratio and wash ratio for dewaxing, dilution and wash solvent ratios for slack wax recrystallization, dilution and wash solvent ratios for wax cake repulping, all must be maintained.

Dewaxing temperatures as low as minus 15° F and wax deoiling temperatures varying from 20° F to 65° F are met by a use of 13 banks of double pipe type scraped surface heat exchangers and 15 banks of double pipe direct expansion chillers. These chillers, plus shell and tube solvent chillers, require 1800 tons of refrigeration.

Centrifugal compressors are used for the refrigeration service and for producing the required differential pressure for the rotary vacuum filters. These two compressors are tandem driven by a 7500 H.P. gas turbine. The hot exhaust from the gas turbine passes through a waste heat boiler, generating sufficient steam to supply all of the unit requirements for pump drivers, solvent heating and product stripping.

TWO-STAGE PROPANE DEASPHALTING

In selecting the processing sequence for production of lube oil base stocks, DX decided on the use of two stage propane fractionation for the preparation of the two



Third step in the modernization program was construction of a 85,000 bpd three-stage crude distillation unit.

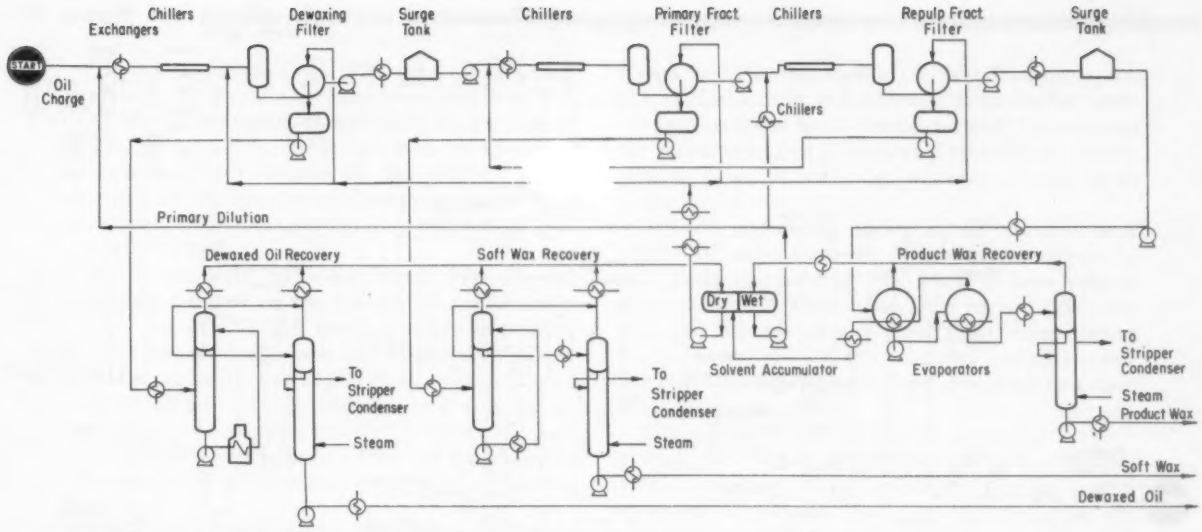


FIGURE 2—The MEK-Toluol process is capable of producing low pour point oils and low oil content waxes simultaneously.

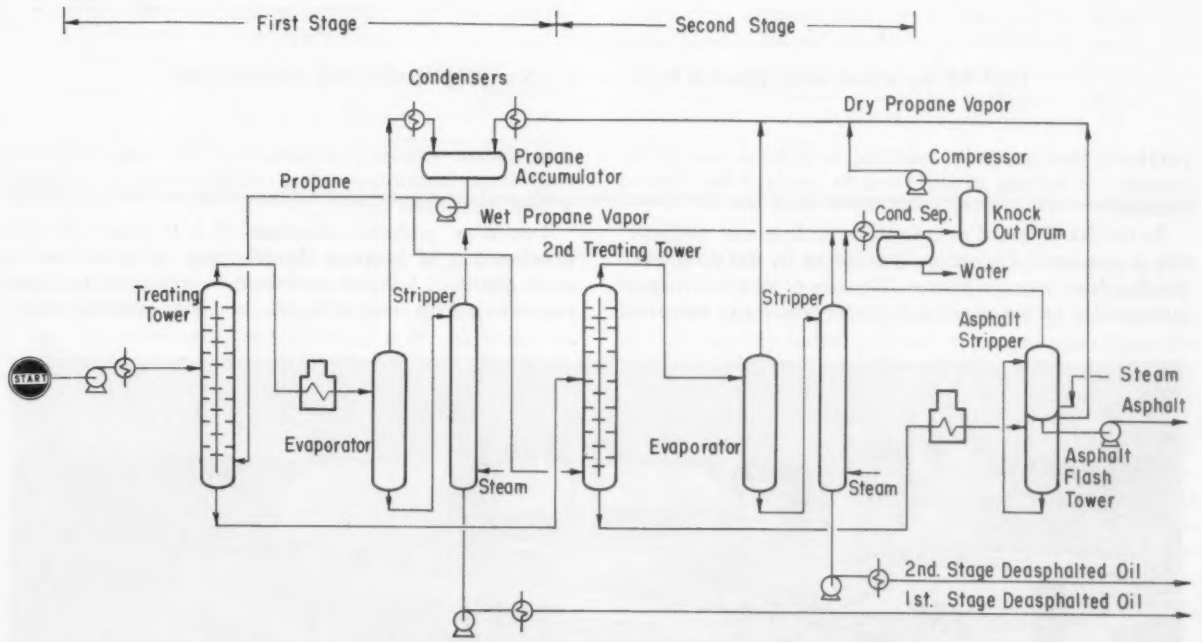


FIGURE 3—The redesigned deasphalting unit was on stream in January, 1961. It produces two grades of lube oil stocks.

heaviest lube oil cuts. In the old operation the lighter of these two stocks had been prepared by vacuum distillation. The decision to change this operation was made largely so that the lube oil base stocks would be subjected to lower temperatures in processing, thereby reducing ultimate finishing costs.

The existing processing facilities included a propane deasphalting unit, using acid treatment in propane solution for finishing of the bright stock. The new deasphalting unit contained an inlet stage to produce the new lube oil base stock and included a redesign of the existing equipment for increased efficiency of separation.

The redesigned deasphalting unit is shown in Figure 3. It uses two rotating disc contactors and produces 2,000 bpd of heavy neutral base stock having 80 SUS viscosity at 210° F and 3,000 bpd of bright stock having 175 SUS viscosity at 210° F from 6,000 bpd of a long residuum from the crude unit.

The rotating disc contactor, RDC, has aroused wide interest in the petroleum industry since it normally provides more extraction stages than the baffle type column normally used for deasphalting or the packed column used for solvent extraction. Extraction efficiency is maintained at all charge rates by varying the rotor speed and tem-

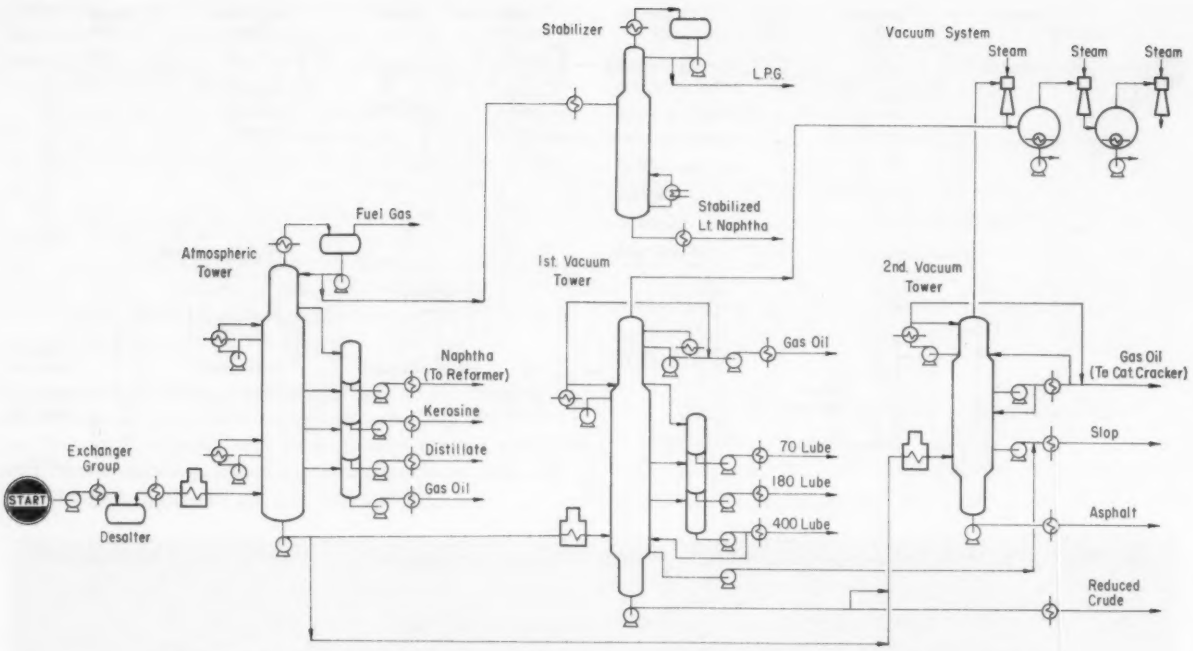
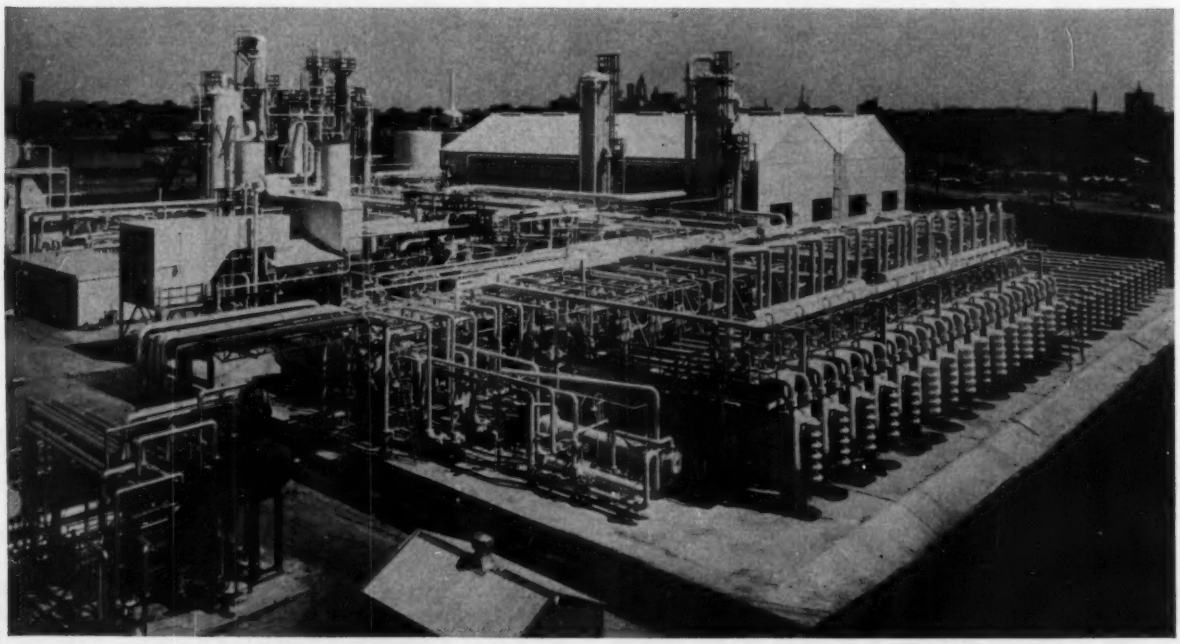


FIGURE 4—Several unique points of design are incorporated in the new crude distillation unit.

perature, thus generally resulting in a reduction in the quantity of solvent circulated to produce the desired product.

In the RDC tower no interstage settling and re-dispersion is employed. Dispersion is achieved by the rotation of the flat discs between stators. The size of droplets formed is controlled by the speed of the rotor which can be varied in operation without shutdown. Flat rotor discs and stator rings create uniform shearing conditions and in obtaining a uniform droplet size.

Two-stage propane deasphalting is a relatively new development of propane deasphalting in which two or more grades of lube oil stocks can be separated by liquid extraction. This unique process not only separates heavy



The new solvent dewaxing and deoiling unit, on stream in August, 1960, is one of the largest units of its kind.

The need for modernization

The free world has, since 1950, seen a tremendous increase in the demand for petroleum products. The 1950 daily consumption of 8,500,000 barrels rose to 17,800,000 barrels in 1960. However, most of this increase has been outside of the U.S.A., where increased industrialization and energy demands have caused petroleum consumption to rise from 2,000,000 to 8,100,000 bpd.

During the years following World War II, the petroleum industry in the United States increased refinery capacity by 54 percent, while petroleum product demands have increased by only 49 percent. This over-capacity has kept refined products generally in over supply. In addition, new and expensive processes such as catalytic reforming and catalytic hydrodesulfurization have been required in refineries to meet demands for higher quality products.

These factors have resulted in a narrowing profit margin for the refiner. As a result, refiners throughout the country have been examining their operations to find methods of reducing costs and improving efficiency in their operation.

The DX Sunray Oil Company, at their Tulsa refinery, first tackled this problem by providing means for more efficient production of high quality gasoline. A $10 million construction program, completed in 1958, included a Unifiner-Platformer, an HF alkylation unit and a butane isomerization unit. As soon as these units started successful operation, the management of DX Sunray turned their attention to lube oil and wax processing facilities at Tulsa.

DX was producing lubricating oil and wax in a variety of units, including a propane deasphalting unit, built originally in 1938; four chlorex solvent extraction units, built during the early 1930s; two isopropyl acetate solvent dewaxing units, dating back also to the 1930's; a wax distillate cold pressing plant; a naphtha centrifuge dewaxing unit, and crystalline wax sweaters.

DX approached the heavy oil modernization program by attempting to determine an optimum processing sequence for a completely modern system designed to produce 6,000 bpd of lubricating oils and to refine high quality waxes from the slack wax separated from these oils. The question was, however, to determine the processing steps that would prove most efficient and would provide the most rapid payout on the complete modernization project. After discussions with various engineering-contracting firms and considerable internal study, DX decided to construct the processing units discussed in this report.

hydrocarbons by molecular size but also to a degree, by molecular type. This separation is made by the difference in the solubility of the required fractions in propane, and is not the same as a separation made by difference in volatility as in vacuum distillation. Thus, the heavy neutral base stock presently produced as a vacuum distillate from the old distillation units, had a lower dewaxed viscosity index than it now does when produced by propane fractionation.

The selective properties of liquid propane can be altered by changing the operation conditions; i.e., temperature, pressure and solvent-to-oil ratio, to obtain the required lube oil product. This process not only produces a higher yield and a higher viscosity index (VI) lube oil fraction, but also operates at comparatively low temperatures eliminating thermal decomposition which might occur in distillation, thus producing lighter colored oils. Inspection data on some typical streams are shown in Table 1.

TABLE 1—Two-Stage Propane Deasphalting of Composite Oklahoma Crude

Stream	°API	Volume Percent on Crude	Viscosity, SSU @ 210° F	Color, ASTM D-1500	Ramsbottom Carbon, Weight Percent
Reduced Crude....	20.8	15.3	250–275	.....	5.7
1st Stage Oil.....	27.0	5.4	78– 82	4.0–4.5	0.35–0.45
2nd Stage Oil.....	22.3	7.3	180–190	6.0–6.5	1.35–1.65
Asphalt.....	5.9	2.6	5,500	.....	.....

Removal of the higher VI heavy neutral base stock will cause the VI of the dewaxed bright stock to be lowered. With the modern lubricating oil market demanding oils of high viscosity index, and with the trend away from the use of bright stock in the motor oil formulation, this method of production of a heavy neutral blending stock tends to improve the refiner's profit margin.

The modernized propane deasphalting plant was placed on stream in January of 1961. During the period before the completion of the new crude distillation unit, it was operated to produce only one lube oil base stock. The two stage operation was started when the new crude unit was placed on stream.

NEW CRUDE DISTILLATION UNIT

The third step in the modernization program was the construction of a new 85,000 bpd three-stage crude oil distillation unit. Construction contract for this unit was awarded to Foster Wheeler in June 1960. The DX refinery at Tulsa formerly processed approximately 75,000 bpd of Oklahoma crude oils through five separate distillation units, built during the late 1920's and early 1930's. Operating costs of these units were high, and separation efficiency was low. The new 85,000 bpd three-stage distillation unit permitted the shutdown of these five units and processes the crude oil much more efficiently.

The total utilities consumed by the present units and the new unit are shown in Table 2. These are representative of the savings which resulted from the new installation.

TABLE 2—Utilities Comparison for the New Crude Unit

	Present 5 Units 75,000 bpd	New Unit @ 85,000 bpd
Fuel, MMBtu/Hr.	500	350
Cooling Water, gpm	20,000	15,000
Steam, Lbs./Hr.	152,000	51,000
Electric Power, Kw.	375	1,275

Several unique points of design are shown in Figure 4. This distillation unit comprises: (a) an atmospheric stage tower, (b) a vacuum tower to produce three well fractionated lubricating oil base stocks, plus a long residue for propane deasphalting feed and (c) a second stage tower operating at minimum absolute pressure and distilling as feed stock surplus atmospheric residuum not required for lube distillate production, plus surplus residuum from primary vacuum tower not fed to deasphalting. In this way, maximum catalytic cracking unit feed stock may be produced from all material not specifically used as lube base stock.

In order to have complete control over the range of boiling point and viscosity of the vacuum distillates to be used as lube stocks, two slop streams are withdrawn, as necessary. In order to assure a well fractionated naphtha for catalytic reformer feed, seven trays are provided between light straight run gasoline and naphtha side stream and eight trays between naphtha and kerosine. The No. 2 vacuum tower has positive wash trays, plus a slop withdrawal between the flash zone and the catalytic cracking unit gas oil to minimize metals or other contaminants in this material.

A material balance for the crude distillation section is given in Table 3.

TABLE 3—Crude Distillation Material Balance

Atmospheric Tower Section Stream	Volume Percent On Charge To Unit
Atmos. Overhead	20.2
Reformer Naphtha	15.9
Kerosene	13.9
Distillate	4.65
Atmos. Gas Oil	7.75
Atmos. Bottoms	37.6
No. 1 Vacuum Tower Section	
No. 1 Vacuum Gas Oil	4.25
D-70 Lube	3.75
No. 1 Vacuum Tower Slop	2.25
D-180 Lube	3.60
D-400 Lube	4.00
Reduced Crude	15.30*
No. 2 Vacuum Tower Section	
Cat. Feed	8.65
No. 2 Vacuum Tower Slop	1.40
Asphalt	3.80

* Reduced Crude Product which is the charge to Propane Deasphalting Unit is 5.9 Volume percent.

SOLVENT EXTRACTION UNIT

The final step of the modernization program will be the installation of a modern solvent extraction process. At the present time lubricating oils are extracted in four separate units, using chlorex as the selective solvent. A characteristic of the chlorex solvent process is the necessity of conducting lube oil extraction at sub-atmospheric temperatures, below the pour points waxy stocks. As a result, the chlorex process requires dewaxed charge stocks. Since dewaxing is a more costly process both from investment and operating cost standpoints, a modern processing scheme will use an extraction process that will process waxy stocks. Hence one of the major reasons for planned replacement of DX's old extraction facilities is the profitability of installing a process which will charge waxy oils. DX is presently preparing specifications for the new extraction unit.

In order to avoid the expenditure of major sums for the installation of complete storage for extracted base stocks between the new extraction unit and the dewaxing unit and to keep inventory of oils in process at a minimum, the new extraction unit will be designed to supply charge to the dewaxing unit at the dewaxing unit capacity on all stocks. Only a minimum surge capacity will be maintained between the two units. The new extraction unit will treat the five base stocks to produce two VI grades from each stock on charge rates of 9,000 to 16,000 bpd. Because of this wide variation on feed rates and the variation in viscosity index of the products, special attention will be given to the design of the extraction columns, so that they can operate with high efficiency under the widely varying conditions.

Key Words for Indexing

Decarbonizing
Deoiling
Distillation
Extraction
Lubricants
Solvents
Waxes

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Use This Check List as Guide for Process Studies

This convenient check list is tailored especially for those concerned with process development. However, personnel in process design and production investigation also may find it useful. Make sure you are not omitting important items in your process evaluation. Use this check list.

W. Dean Robinson
Monsanto Chemical Company, St. Louis

This convenient check list is the result of years of thinking in the field of process development. Here are some of its uses:

- **A basis for devising one's own list of items to be checked in any particular study.**
- **A check on completeness of thinking and experimentation.**
- **An aid to program planning.**
- **An indoctrination for those less experienced in process research.**
- **A review and refresher for the more seasoned engineer and chemist.**

An important objective of this check list is to promote more questions to be asked of our process development studies rather than to set forth iron-clad criteria for an experimenter to follow. The list evolved in the laboratories of Monsanto Chemical Company's Organic Chemical Division to fill a need for insuring that process studies are as complete as possible without being stereotyped.

Many of the questions and perhaps whole sections will not apply to some process studies. The need for sales samples and thus a process in a few days, or a week, may preclude the answering of all but a few items. Conversely, to anticipate all the difficulties to be encountered in the vagaries of a new process would be impossible.

The quest for a satisfactory process will remain with the chemist and engineer. Yet, the chemist and the engineer will be among the first to admit that neglect in the consideration of some of the questions in this list has cost the chemical industry millions of dollars in process troubles. Perhaps worse, such oversights can and have cost chemical companies the competitive advantage of getting to market first with the best product and technology.

A Handy Check List for Process Development

GOAL DETERMINATION

____Should goal be written?
____Should goal be divided into more specific sections?
____Is it necessary to confer with others on general goal?
____Do the following need to know more about the proposed process or change:
Production?
Engineering?
Development?
Sales?
Supervisor?
____Is there a more important goal to reach first?
____Would the sought-after process or process change, if achieved, be adequate to achieve the goal?
____Where should this process or process change be developed:
Pilot Plant?
Plant?
Laboratory?
____When should the objectives be reviewed again?
____Is a time limit needed in the objectives?

ANALYSIS OF PROBLEM

- ——Does the problem really exist?
- ——Does the problem need to be more clearly defined?
- ——Should the problem be written?
- ——Should the general problem be divided into parts?
- ——Is the sales volume of product known?
- ——Is the projected sales volumes known?
- ——Should price range be estimated?
- ——Are any known factors setting maximum price?
- ——Are there competitive products?
- ——Does the product fit into the company product groups?
- ——Are end uses known?
- ——Is the product likely to be replaced by another?
- ——How does marketing outlook effect type of process?
- ——Does sales volume and price warrant possible manufacture in:
  - Intermediate production plant?
  - Other existing equipment?
  - New plant?
  - Batch equipment?
  - Continuous equipment?
  - Readily expandable equipment?
- ——How should economic outlook effect amount of work on process or process change?
- ——As a guess, what should be the maximum time expended?
- ——Will the process be used in a new plant, or will the process change have to justify obsolescence of capital?
- ——Will the relative cost of possible raw materials point toward a high yield process? A low conversion cost process?
- ——Is more literature searching needed and warranted?
- ——Can a literature searcher be of help?
- ——What is the patent position of the product or process change?
- ——Might anybody in the department, or the company, have special knowledge on the type of process or process change?
- ——Can plant records be used to more advantage?
- ——Would a consultant help?
- ——Have the possible chemical routes or methods been listed?
- ——Are there any unique possibly more advantageous routes? Or methods?
- ——Has the thinking been broad enough, unhampered by previous results?
- ——Would a brainstorming session be worthwhile?
- ——Can more favorable chemistry be gained by using:
  - Nitration?
  - Amination by reduction (by amonolysis)?
  - Halogenation?
  - Diazotization and coupling?
  - Sulfonation?
  - Oxidation?
  - Hydrogenation?
  - Alkylation?
  - Esterification?
  - Hydrolysis?
  - Polymerization?
  - Dehydrogenation?
  - Dehydration?
  - Reforming?
  - Cracking?
  - Catalysts?
  - Vapor Phase reactions?
  - Other reactions?
- ——Can physical separation be carried out more easily by:
  - Evaporation (multi-effect, film, thermo-syphon, submerged combustion, forced circulation)?
  - Diffusion?
  - Simple distillation?
  - Fractional distillation (azeotropic, solvent)?
  - Drying (flash, freeze, spray, drum, kiln)?
  - Gas absorption (solvent, column)?
  - Adsorption (carbon, alumina, silica gel, molecular sieves)?
  - Extraction (liquid-liquid, gas-liquid, solids)?
  - Filtration (centrifugation)?
  - Crystallization?
  - Entrainer distillation (steam)?
  - Condensation (differential, equilibrium)?
  - Sublimation?
  - High vacuum distillation?
  - Decanting?
  - Hydraulic separation?
  - Settling?
  - Ion exchange?
  - Dust or mist collection (cyclones, filters)?
  - Screening?
  - Other?
- ——Are kinetic data available?
- ——Are physical constants available for product and possible raw materials?
- ——Are the quality limits of the product defined as much as possible?
- ——Is there need of application studies before much work is expended on process work?
- ——Does the development of the process or change require extra safety precautions?
- ——Are any of the raw materials toxic? Product?
- ——Are intermediates unstable? Raw materials? Products? Residues?
- ——How do the various alternatives compare as to attributes of a good process? (See "Re-evaluation")
  - Economical?
  - Simple?
  - Adaptable?
  - Reliable?
  - Safe?
  - Adequate?
  - Expandable?

EXPERIMENTATION

General

- ——Is it well to review the goal or objective?
- ——How can the objectives be reached most surely and efficiently?
- ——Can the various routes be compared in the laboratory?
- ——May any of the routes be conducive to quick chemical yield improvement?
- ——Must some testing of possible processes be made before comparisons of routes can be made?
- ——Must feasibility be tested?
- ——Should the most profitable

OPERATION	Mole Wt.	DENSITY: Actual	DENSITY: Bulk	B Volume vs. Temp.	Viscosity	Consistency + Flow	Specific Heat	Thermal Conductivity	Surface Tension	Diffusivity	Emissivity-Radiation	Vapor Pressure Curves	HEAT DATA: Reaction	HEAT DATA: Solution	HEAT DATA: Fusion	HEAT DATA: Vaporization	EQUILIBRIA DATA: Vapor-Liquid	EQUILIBRIA DATA: Liquid-Liquid	EQUILIBRIA DATA: Liquid-Solid	EQUILIBRIA DATA: Vapor-Solid	RATE DATA: To Equilibria	RATE DATA: Phys. Flow	Efficiency Data	Temp. Sensitivity	Regeneration Studies	Buildup of Impurities	Foam-Liquids	Solids Fracture Dust	Particle Size Distrib.	Explosion Hazards	Health Hazards	REMARKS AND FURTHER INFORMATION DESIRED
Absorption, Gas	o	x			x		x		o	o		x	x	x		x	x						o	x			o	x	x	x	Apparatus dimensions, flows, compositions
Adsorption, Gas + Liquid	o	x	x		x		x					x		x		x	x		x	x	x	o	x	x	x	o		x	x	x	Bed saturation vs. break point
Calcination, Solids		x	x				x					x	x			x			o	x			x	x			x	x	x	x	
Classification, Settling		x	x		o																	x	x					o	o	o	Coagulation, Settling Curves, % Solids
Flotation									o																		x		o	o	o	Anionic + cationic collectors for particles, etc.
Condensation	o	x			x		x	x				x				x	x												o	o	o	Compositions, Temps., Rates
Crushing + Grinding		o	x			x																		o				x	x	x	x	Screen analyses, Brinell hardness, moisture
Crystallization		o	o		o		x					x		x		x	x		x		x	x	x			x	o	x	x	o	x	Batch cooling curve, seeding, super saturation, recycle, mother liquor, centrifugation of crystals
Distillation	x	x			x		x	x	x			x		x		x	x	x				o	x	x			x		x	o	Apparatus dimensions, flows, compositions, press, temps.
Drying	o	o	x			x	x	o		o		x				x			o	x	x		x	x				x	o	x	x	Equilib. moist. vs. humidity, drying rate curves, caking, etc.
Dust + Mist Collection	o	x	x		x	o																	x	x					x	x	x	Loading in Gas, electrostatic properties and conductivities
Evaporation	o	x			x	o	x	x	x			x		x		x	x	o	o			o		x		o	x			x	o	Crystallization, scale formation, evolution gas, etc.
Extraction by Liquids	o	x			x					o				x				x	x		x	x	x				x			o	x	Emulsions, coagulents, solids in liquids, etc.
Filtration		x			x	x						x					x		x			x	x					o	o	o	x	Nature of solids, % solids, agglomeration, plugging filter medium, precoat, filter aid, filtration & washing cake data at various press. + temp.
Flow + Storage-Liquids	o	x			x		o					x					o		o										o	o	Non-Newtonian, slurry, freezing point, changes on aging
Flow + Storage-Solids		o	x			x						o																o	o	x	x	Angle of repose, caking upon storage, dusting, temp.
Flow of Heat	o	x		o	x		x	x	o		o		x	x	x	x												o	o			Temperature level of heat transfer
Ion Exchange		x	x		x									x					x		x	o	x	x	x			x	x			Lab curves, bed sat. vs. break point, resin life
Mixing + Blending		x	x		x	x								x				o	o				x						x	o	o	Order of phase addition, uniformity of product
Reactor Design	x	x	x		x	o	x	x	o	o		x	x	o	o	o	x	x	x	x	x	o	x	x	o	o	o	o	o	x	x	Complete description of apparatus + expt'l work, reaction rates at temps + press, catalyst poisons and life, etc.
Screening		o	x			x																	x					x	x	x	x	Moist content, static electrical effects, etc.
Sublimation + Desublimation	o	x	x			x	x					x			x	x				x	x	o	x	x				x	x	x	x	Triple point, crystal growth rates vs. particle size, complete phase diagram, etc.

Notes: x = properties most commonly required
o = properties less commonly required

Basic items such as temperature, pressure, material balance, data for heat balance & material of construction are always required.

Courtesy A. J. Lobdell, Monsanto Chemical Co.

FIGURE 1—Information needed for design of certain unit operations in a process may be listed on a chart similar to this one. Notice there are some overlapping operations, i.e., absorption includes pressure drop and flow of fluids.

methods even though the most unlikely be tested first?

____Would statistically planned experiments help?

____Should the Statistics Group be consulted?

____Would the digital or analog computers help?

____In setting up the experiments, is the recording of the maximum warranted amount of data planned?

____Are the variables to be measured with the highest feasible accuracy?

____Besides the main objectives, can the following be noted without too much effort—even in initial experiments?

- Volumes?
- Temperatures?
- Pressures?
- Viscosities?
- Bulk densites?
- Specific gravities?
- Heat evolution?
- Heat requirements?
- Temperature sensitivity?
- Foaming characteristics?
- Moisture contents?
- Ease of handling?
- Crystal size-distribution?
- Pumpability?
- Agitation characteristics?
- Gas evolution?
- Scaling or fouling of heat transfer surfaces?
- Phase changes?
- Solids precipitation?
- Freezing points?
- Chemical yield?
- By-product distribution?
- Material balance?
- Determination of amount and character of losses?
- Corrosion?
- Others?

____Is proper consideration given to physical changes (unit operations) as well as chemical changes?

____Can any of the operations advantageously be:

- Eliminated?
- Combined?
- Simplified?
- Rearranged?

____Is consultation needed with any of the following before proceeding too far?

- Process engineer?
- Production supervisor?
- Corrosion expert?
- Research engineer?
- Pilot plant man?
- Technical director?
- Instrument group?
- Analytical methods group?
- Safety director?
- Kinetic expert?
- Mechanism expert?
- Supervisor?

____Is it well to seek the interest and cooperation of those who are to use the research?

____In the detailed examination of any process or major process change, are the following areas worthy of special consideration?

Raw Materials

____Should raw materials and reagents be the same as in plant usage?

____Are source and lot numbers of all materials known?

____Are the compositions known?

____Should refined materials be compared to crude materials?

____Can any of the raw materials be eliminated?

____Can unnecessary reagents be eliminated?

____Would crude raw materials be more profitable?

____Should more available raw materials be used?

____Are all contemplated materials available commercially?

____Should company products be used?

____Should liquids be used instead of solids?

____Are more concentrated materials needed?

____Should intermediate be bought instead of raw materials?

____Should own raw material be produced?

____Is there a more convenient physical form?

____Should unreacted materials be recovered?

____What quality requirements (specifications) should be set for raw materials and reagents?

____Should process be developed using more basic material?

____What safety precautions should be used in handling and storing materials?

____Is any property of materials or reagents not already considered likely to cause difficulty on larger scale?

____Should anyone be consulted on the raw materials to be used in the study?

Sequence of Operation

____Should order of reactions (unit operations) be changed? i.e.:

- Purify while reacting
- Transport while reacting or treating
- Flash dry while transporting solids
- Cool while concentrating by lowering pressure
- Pipeline neutralizer

____Would dividing the reactions (unit operations) help? i.e:

- Series operation to promote efficiency
- Evaporate in a specially designed unit rather than a glass-lined reactor
- Stage reactors

____Can continuous flow processing help?

____Should buffer storage be provided or eliminated?

____Should need for pumps be eliminated?

- Use gravity flow?
- Use Pressure transfer?
- Use air lift?

____Should recycle streams be reduced?

____Should batch size be increased?

____Should liquids be transported instead of solids?

____Should process be made more amenable to automatic flow controls?

____How will an upset in one operations affect another?

____Consider need for automatic shutdowns?

____Consider difficulty of translation pilot plant? Plant?

____Is the sequence of operations attainable in large equipment?

_____Is the effect of storage between operations in large scale production to be checked?

_____Will intermediate or product deteriorate in series operations?

_____Will the effect of sequential operation and usual plant delays be checked in laboratory?

_____Will sequence of operations likely cause trouble on larger scale for any other reason?

_____Is it well to check the possible sequence of operations with:

Engineering?
Pilot plant?
Production?
Supervisor?

_____Is it well to check through the proposed sequence of operations before testing, or translating, to foresee any overlooked need or difficulty?

_____Is it well to project oneself into the future?

_____Should a dry run be made?

_____Can a tenative flow sheet be made?

_____Should the flow sheet include amounts of materials, volumes, equipment conditions?

_____Under what conditions may the process be shut down for short times? For long times?

Operational Methods

_____Will the operation to be studied best fulfill the goals?

_____Is there any unique and better way?

_____Is there a different method of reacting as in:

A fractionation column?
A plug-flow reactor?
The vapor phase?
An extraction column?
A continuous process?
A fluid bed?

_____Will the test of the operation provide the basis for larger scale?

_____Are the independent (controllable) variables recognized?

_____Are all the worthwhile dependent variables to be measured?

_____Are all the conditions to be varied over a wider range than can be visualized in larger scale production?

_____What would be the effect of:

Erroneously changing the order of additions?
Of changing the order of the heating and cooling cycles?
Of adding contaminants?
Of skipping a step?
Of forgetting a reagent?
A raw material?

_____Are the larger scale time cycles to be duplicated in the smaller scale?

_____Should tests in the smaller scale check effect of usual plant delays?

_____Will there be longer cooling, heating and adding time in the plant? What effects?

_____Should limits of operability be ascertained in the laboratory?

_____Will the data give the:

Chemical yield?
By-product distribution?
Material balance?
Determination of amount and character of losses?
Satisfy the objectives?

_____Should the following be measured:

Volumes?
Temperatures?
Pressures?
Viscosities?
Bulk densities?
Specific gravities?
Heat evolution?
Heat requirements?
Moisture contents?
Gas evolution?
Freezing points?
Crystal size distribution?

_____Is it necessary to get the data listed on the chart entitled "Information Desired for Design of Unit Operations" as shown in Figure 1?

_____Should these factors be checked:

Temperature sensitivity?
Ease of handling?
Pumpability?
Agitation characteristics?
Fouling of heat transfer surfaces?
Phase changes?
Solids precipitation?
Decomposition?
Effect of mixing air with goods?

_____How does yield, conversion and quality vary with times, temperatures, pressures and concentrations?

_____Are plots of the relationships worthwhile?

_____Are response surface plots warranted?

_____Is the effect of metal surface to be tested?

_____Will the operational controls be adequate and feasible for larger scale?

_____Can the temperature conditions be made so that ordinary cooling water may be used rather than chilled water?

_____Can normal steam pressures be used?

_____Will the skin temperature of heating surfaces cause decomposition?

_____Will the skin temperature of cooling surfaces cause unwanted condensation-water? Precipitation?

_____Are saturated solutions involved which will cause blockage when in contact with cold walls, valves, flanges?

_____What are the consequences of water in the system?

_____Are the pressures readily attained in plant equipment?

_____Are the disposal of hazardous by-products, the recovery of solvents, residues, etc., a problem?

_____Will there be fumes?

_____Should a dry run be made?

_____Are there any foreseeable difficulties?

_____Would better control of the variables give better yield, quality, etc.?

_____Are analytical control methods needed?

_____Are the samples to be taken adequate?

_____Will the effect of the buildup of contaminants on the reactions be considered?

_____Are adequate safety precautions to be taken?

_____Is it well to check the operational methods with:

Engineering?
Pilot plant?
Production?
Supervisor?

Equipment

- ____Will the equipment used in the study adequately "mock-up" the larger unit?
- ____Can simpler lower cost equipment be used in the plant?
- ____Is continuous processing equipment likely to be specified?
- ____Are materials of construction to be found?
- ____Should not the objective of testing materials be to try to induce corrosion under all conditions of the process?
- ____What is the effect of the construction materials on the process yield, conversion, quality?
- ____Is it well to test the material of construction for fractionating stills by burying a rod the full length of the laboratory packed column?
- ____Should the materials for a condenser be tested under actual heat transfer tests?
- ____Should any other "wind and wave" zone be checked for corrosion more thoroughly?
- ____Will the effect of the buildup of contaminants or chlorides as a corrosive agent be considered?
- ____Will the Staff Corrosion Expert be consulted?
- ____Will the greater ratio of contained volume to heat transfer area in the larger pot affect the operation?
- ____Will the greater ratio of volume to disengaging area in the larger pot have an effect?
- ____Would the use of a heat exchanger effect the ratio of metal surface to goods?
- ____Will type of agitation effect process?
- ____Will ordinary pump packing hold the goods?
- ____Is consulting with other persons who have set up similar type of equipment worthwhile?

Products

- ____Are the quality specifications determined?
- ____Does satisfactory product result using projected time cycles?
- ____Is the product prepared in the investigation to be tested in its ultimate use?
- ____Is the physical form of the product adequate.
- ____Does it cake or deterioriate on storage?
- ____Are any special types of container needed?
- ____What is the bulk density? Crystal size distribution? Pounds per gallon?
- ____Will contaminants such as trace metals or fly ash cause stains upon storage?
- ____Is product sensitive to conditions of storage—temperature, humidity?
- ____Will better quality have a selling advantage?
- ____Should the Sales and/or the Development Departments be contacted on quality?

RE-EVALUATION

- ____Does the process development study fulfill the goals?
- ____How does the developed process rate in the attributes of a good process as listed:

Simple:

- ____Minimum number of reactions.
- ____Minimum number of unit operations.
- ____No complicated equipment causing high cost repairs and shutdowns.
- ____Generally simple reactions.
- ____Easy to control.

Adaptable:

- ____Process is usable in available equipment.
- ____Adaptable to a wide range of production volumes.

Reliable:

- ____No cause for intermittent operation.
- ____Stability of yield, quality, etc.

Economical:

- ____Most profitable.
- ____Must have other attributes as well to have long range profitability.
- ____Low capital.
- ____Low cost.

Safe:

- ____Moderate conditions.
- ____All safety precautions specified.

Adequate:

- ____A complete process—no loose ends.
- ____The areas of doubt known and risk evaluated.
- ____Gives product of adequate quality and volume.

Reported:

- ____Process report published.
- ____Engineering study published.
- ____Laboratory final report available.
- ____All hazards reported.
- ____The process sold to user.

Expandable:

- ____Cost and capital savings from expansion.
- ____Larger units feasible.

Robinson

About the Author

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Key Words for Indexing

Design, Developments, Reviewing, Verifying

Use This Method to Size Each Stage for Best Operation

A poor decision about one stage of a multistage unit will affect each successive stage. It is important then to learn how "dynamic programing" will help better allocation decisions

Gerald T. Westbrook
Dow Chemical Company, Midland, Mich.

A relatively new technique now is available for making the proper decision about each step of a multistep process. Called "dynamic programing" (DP),[1] the new technique or calculation algorithm gives the optimal sequence of decisions for any condition of a system rather than for only a few fixed conditions.

In many processing sequences, a poor decision at one stage will plague the process for the remainder of the sequence. When this is realized, then it is easier to see the importance of making the right decision for each step. The DP method uses a series of functional equations so that their solution gives the optimal policy.

HOW DYNAMIC PROGRAMING WORKS

Many allocation problems have been successfully studied with the aid of linear or non-linear programing. Now dynamic programing (DP) also has been used in several industrial problems. This has lead to a new approach to some rather old problems, with some interesting results. A list of recent publications on the use of DP in the solution of multistage decisions is reviewed in Table 1.

A general expression for the DP method may be developed by letting $g_j(x_j)$ be a functional definition of the profits resulting from the allocation of x_j units of material x to stage j. The conventional objective function would be of the form:

$$Z = f(x_1 x_2 \ldots x_n) = \sum_{j=1}^{n} g_j(x_j) \qquad (1.1)$$

to be maximized subject to:

$$\sum_{j=1}^{n} x_j \leqslant x, \text{ and } x_j \geqslant o, \text{ where } j = 1,2,\ldots n \qquad (1.2)$$

The DP method restates the objective function as:

$f_n(x)$ = maximum profit attainable from a process having n stages and starting with an initial quantity x.

$$f_n(x) = \text{maximum} \sum_{j=1}^{n} g_j(x_j) \qquad (1.3)$$

A typical set of the functional equations is:

$f_n(x) = \text{maximum of } [g_n(x_n) + f_{n-1}(x - x_n)]$
where $o \leqslant x_n \leqslant x$

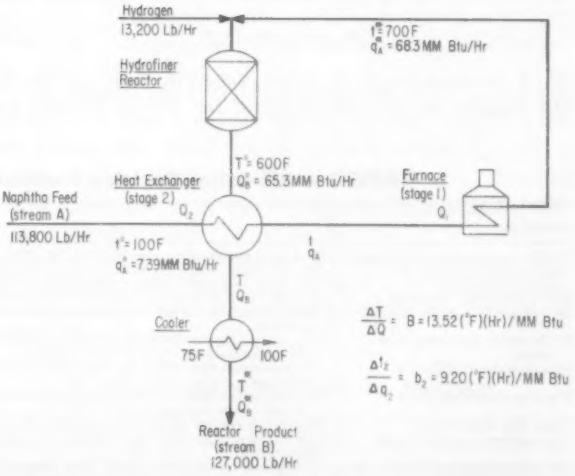

FIGURE 1—The problem is to find the proper amount of heat to transfer from the effluent to the feed in order to minimize the costs of the system.

$$f_{n-1}(x) = \text{maximum of } [g_{n-1}(x_{n-1}) + f_{n-2}(x - x_{n-1})] \quad \text{where } o \leq x_{n-1} \leq x \tag{1.4}$$

. . .

$$f_1(x) = \text{maximum of } [g_1(x_1)] \quad \text{where } o \leq x_1 \leq x$$

If $g_j(x_j)$ is a reasonably well behaved function some analytic solutions are possible. Barring this, the most common practice is to start with the last equation and establish $f_1(x)$ in tabular form for the region of x of interest. The first equation can then be used (for $n = 2$) along with the table for $f_1(x)$ to obtain a second table for $f_2(x)$. This process can be repeated for as many stages as required.

The Allocation Problem in Multistage Heat Exchange

In large petrochemical plants and refineries there inevitably are many process streams at varying temperature levels. These may need to be cooled or reheated before further use. There are many ways these objectives could be achieved, but generally it is advantageous if the stream to be cooled can be used to heat some other stream. In this fashion both fuel costs and cooling water costs can be reduced. It is then a matter of establishing whether these savings can pay for the cost involved in the exchange of heat between the two media.

It will be assumed that the reader is familiar with the principles of heat transfer such as outlined in Kern.[8]

FIRST APPLY A SINGLE DECISION TECHNIQUE

Although we are principally interested here in the case of multidecision heat transfer problems, it will be fruitful to consider initially the single decision problem. This problem is illustrated in Figure 1. Here, stream A at temperature t^o, and heat content $q_A{}^o$, must be heated to a temperature t^* with a heat content of $q_A{}^*$. Thus a total amount of heat:

$$Q = q_A{}^* - q_A{}^o \tag{1}$$

must be added to A. Part of this heat can be picked up from a hot stream B. This is at a temperature T^o with heat content $Q_B{}^o$ and it must be cooled to T^* and $Q_B{}^*$. Hence, the total amount of heat available in stream B is

$$R_B = Q_B{}^o - Q_B{}^* \tag{2}$$

If all the heat required, is not picked up from stream B, the balance of the heat demand for stream A must be added in a furnace. That is:

$$Q = Q_1 + Q_2 \tag{3}$$

Thus the problem here is to find the optimal heat allocation to stage 2, Q_2, that minimizes the costs of the system. The value of Q_2 affects every cost for this process. These costs are:

Exchanger Equipment Cost. This cost can be directly correlated with the amount of heat transfer area A, that must be built into the equipment. This area is given by:

$$A_2 = \frac{Q_2}{U_2 \Delta_2 F_2} \tag{4}$$

U_2 = Heat transfer coefficient between streams A and B at the prevailing temperatures and flows in the exchanger.

Δ_2 = Logarithmic average temperature difference between A and B.

$$= \frac{(T^o - t) - (T - t^o)}{(T^o - t)/(T - t^o)} \tag{5}$$

F_2 = Temperature difference correction factor

$$= \frac{\sqrt{R^2+1}\ \ (1-S)/(1-RS)}{(R-1)\ln\left[\dfrac{2-S\,(R+1-R^2+1)}{2-S\,(R+1+R^2+1)}\right]} \tag{6}$$

$$\text{where } R = \frac{T^o - T}{t - t^o} \tag{7}$$

$$S = \frac{t - t^o}{T^o - t^o} \tag{8}$$

TABLE 1—Allocation Decision Problems in the Hydrocarbon Processing Industry

Problem	Allocation Process	Reference
Multi-stage compressor design	The total pressure increase required is allocated to the various compressor stages to minimize energy requirements.	2
Multi-station natural gas pipe line design	The minimum cost pipe line system can be achieved by an optimal allocation of a complex factor equivalent to the total pressure (squared) differential required for the system.	3
Batch filtration operation	An allocation of time in a filtration cycle will maximize production of the filter cake.	3
Multiple effect evaporation	The optimal allocation of solvent evaporated from each stage will minimize steam requirements or maximize total evaporation.	3
Multi-stage heat exchanger trains	In a multi-stage train, where a main stream is preheated via several other streams, the optimum heat allocation policy will minimize total costs for the system.	3
Heavy water distillation	The minimum feed water load per unit of D_2O produced can be achieved by an optimal allocation of D_2O enrichment per stage.	1, 4
Cross current extraction	If a restriction exists on the volume of solvent available, the extraction can be maximized by optimally distributing this solvent to the various stages.	2
Fixed bed adsorption	Problem is similar to the catalyst replacement one.	3
Homogeneous reactor train	The factor allocated to each reactor is a percentage of the total conversion desired, with minimum system costs as the objective.	5
A stochastic analysis for a batch reaction sequence	The maximum expected return from a reaction sequence subject to random failures can be achieved by establishing the number of batches to prepare at each stage in the sequence.	6
Catalyst Replacement Problem	The optimal catalyst replacement policy will result from an allocation of operating time of the reactor to catalyst of a given age.	7
Equipment Replacement	If the life expectancy of any depreciable item is much less than that of the function it serves, it will have to be replaced several times. A decision is then required to define the number of changes to maximize profits accrued from the function.	3

As more heat is allocated to this stage both the temperature of stream A and B must from necessity change. That is:

$$T = T^{o} - \psi(Q_2) \tag{9}$$

$$t = t^{o} + \phi(Q_2) \tag{10}$$

The nature of these functions will depend on the physical properties of each stream. An inspection of the above series of equations would indicate that A_2 will increase rapidly with increase in Q_2, since the numerator of Equation (4) will rise and the denominator fall.

After Cooler Cost. The same form of Equation (4) would give the area required in this cooler. However, as Q_2 is increased the duty of this cooler, Q_2^*, will fall and hence so will its cost, e.g.

$$Q_2^* = R_2 - Q_2 \tag{11}$$

Cooling Water Costs. These are directly proportional to Q_2^* and, therefore, will be opposite to the initial cost.

Furnace Cost. This varies directly with Q_1 and, therefore, will fall as Q_2 rises.

Fuel Cost. Variation the same as the furnace cost.

Although the above equations are lengthy, they are quite standard. Thus, the optimal allocation policy for this problem can be obtained by computing all the costs for a given Q_2, and repeating these for several values within the region of interest.

NOW TRY THE DYNAMIC PROGRAMING TECHNIQUE

Consider this problem, however, when multidecisions are required. These arise when multistage heat exchange trains are used. Two types of processes are possible as illustrated.

Case 1 (Figure 2)—Occurs when N — 1 hot auxiliary streams are available to heat up a cold main stream.

Case 2—This occurs when N — 1 cold auxiliary streams must be heated and one main hot stream exist and can be used for this purpose.

In both problems the objective is to find the optimal heat allocation policy at each stage to minimize the total costs of the system. It is easy to see any decision made at a given stage will affect the remaining system, since it would alter the temperature and heat content status at each stage. For example, in the Type 1 process, it might occur that if too much heat were added in the initial low temperature stage, the main stream temperature would rise to an extent that successive Δ_j's would fall and hence the costs of these stages rise.

Thus this problem is ideal for a dynamic programing formulation, for given the fixed specifications on each auxiliary stream the optimal allocation policy at stage j, must depend alone on the state of the feed to that stage. Let $g(Q_j)$ define the costs in stage j resulting from an allocation of Q_j units to that stage. The objective function for this problem is:

$$\text{Minimize: } g(Q_1) + g(Q_2) + \ldots g(Q_n) \tag{12}$$

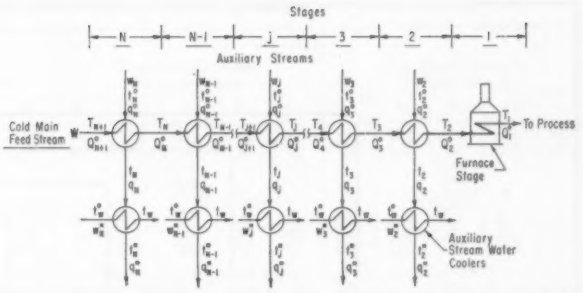

FIGURE 2—Any decision made at one stage will affect the remaining system since it would alter the temperature and heat content status at each stage.

$$\text{Subject to: } Q_1 + Q_2 + \ldots Q_n = Q$$

$$o \leqslant Q_j \leqslant R_j \qquad j = 1 \ldots N$$

Define the minimum cost as:

$$f_N(Q^{o}_{N+1}) = \begin{Bmatrix} \text{The minimum cost for an N stage heat exchanger train, with feed heat content of} \\ Q^{o}_{N+1}, \text{ and required heat content of } Q_1^{o} \end{Bmatrix}$$

Applying the principle of optimality:

$$f_N(Q^{o}_{N+1}) = \text{Minimum of } [g(Q_N) + f_{N-1}(Q^{o}_{N+1} + Q_N)] \tag{13}$$

$$\text{where } Q_N < R_N \text{ and } Q_n < (Q_1^{o} - Q^{o}_{N+1})$$

" " "

" " "

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$$f_2(Q_3^{o}) = \text{Minimum of } [g(Q_2) + f_1(Q_3^{o} + Q_2)] \tag{14}$$

$$\text{where } Q_2 < R_2 \text{ and } Q_2 < (Q_1^{o} - Q_3^{o})$$

$$f_1(Q_2^{o}) = g(Q_1) = g(Q_1^{o} - Q_2^{o}) \tag{15}$$

A table (for stage 1) can be calculated immediately for the desired range of Q_2^{o}. Another table can be calculated next for a range of values of Q_3^{o}. For each Q_3^{o}, some Q_2 will exist to give the minimum in Equation (14). This can be tabulated along with f_2 and Q_3^{o}. Note that this optimal policy, Q_2, is also a function of the feed condition.

This process can be repeated until all tables are established. It is then a simple matter to enter table N with the known feed condition Q^{o}_{N+1} and obtain Q_N, since

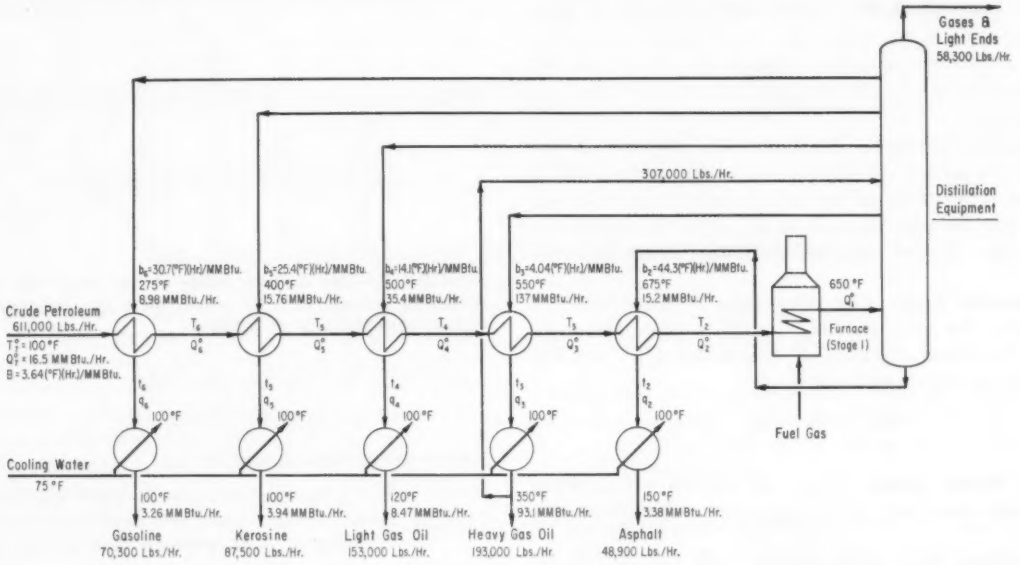
$$Q_N^{o} = Q^{o}_{N+1} + Q_N, \tag{16}$$

the feed to the next stage becomes known and table N — 1 can be entered to obtain Q_{N-1}.

In this fashion, the optimal policy for each stage can be readily found. Equations (9) and (10) can then be used to determine the optimum temperatures T_j and t_j, out of each stage.

A COMPUTER PROGRAM IS DEVISED

A computer program to obtain the optimal heat allocation policy for an N stage process has been designed based on Equation (13). This was programmed on a digital computer at the University of Minnesota's Numerical Analysis Center. The cost function in this equation for any stage j, $g(Q_j)$ was defined[3] by:



Variables

- T_j Main Stream Interstage Temp., °F
- t_j Aux. Stream Interstage Temp., °F
- Q°_j Main Stream Interstage Heat Content, Btu/Hr.
- q_j Aux. Stream Interstage Heat Content, Btu/Hr.
- Q_j Heat Alloted to Stage j, Btu/Hr.
- Q^*_j Heat Removed by Aux. Cooler j, Btu/Hr.
- W^*_j Water Flow in Cooler j, Lb/Hr.

Parameters

- T_{N+1} Main Stream Feed Temp., °F
- T_1 Main Stream Req'd Process Temp., °F
- t°_j Aux. Stream j Inlet Temp., °F
- t^*_j Aux. Stream j Req'd Outlet Temp., °F
- t°_w Cooling Water Inlet Temp., °F
- t_w Cooling Water Outlet Temp., °F
- Q°_{N+1} Main Stream Feed Heat Content, Btu/Hr
- Q°_1 Main Stream Req'd Heat Content, Btu/Hr
- q°_j Aux. Stream j Inlet Heat Content, Btu/Hr
- q^*_j Aux. Stream j Outlet Heat Content, Btu/Hr
- w_j Aux. Stream j Flow Rate, Lb/Hr
- W Main Stream Flow Rate, Lb/Hr

Notes

$R_j = q^\circ_j - q^*_j$

$Q_j + Q^*_j = R_j$ The total heat to be removed from Stream j.

$Q_j = Q^\circ_j - Q^\circ_{j+1} + q^\circ_j - q_j$

$Q = Q^\circ_1 - Q^\circ_{n+1} = \sum_{j=1}^{n} Q_j$

FIGURE 3—A distillation operation represents a problem in which several exchangers are interdependent. Note: In this example, two values were used for Q°_1 (248 MM Btu/Hr and 150 MM Btu/Hr). The asphalt rate was doubled for Case 9. Water cost was 1¢ per thousand gallons and fuel cost was varied (1 - 30¢ per million Btu).

$$g(Q_j) = \begin{cases} \dfrac{270}{P_F}\left[n_j\sqrt{A_j} + n_j^*\sqrt{A_j^*}\right] + 0.04\ p_w(R_j - Q_j), & \text{exchanger stage} \\ \dfrac{10{,}600}{P_F}(Q_j)^{0.715} + 8.33 \times 10^{-3}\ p_f Q_j, & \text{furnace stage} \end{cases} \quad (17)$$

where

$g(Q_j)$ = The total annual cost charged against stage j

P_F = Present worth factor $= \dfrac{(1+i)^n - 1}{i(1+i)^n}$

$\dfrac{1}{P_F}$ = Could be thought of as the annual yield or percent return required for the process

n = Expected service life of the facility

n_j = Number of exchanges required in stage j

n_j^* = Number of coolers required in stage j

p_w = Price of cooling water $/M Gal.

p_f = Price of fuel $/MMBtu

A_j, A_j^* are defined by Equation (4)

Example 1—Petroleum Distillation Preheat Train. As an example of the utility of this type of analysis, consider the design of a six stage preheat train in a petroleum distillation process. This process is illustrated in Figure 3 along with basic numerical data.

In all, nine cases were studied where the data in Figure 3 was slightly altered from case to case. The object (of these changes) was to observe how the optimal heat allocation policy might be influenced. In a practical problem this would be of considerable import since quite often many of the so called constant parameters are actually rather intangible. Thus the probable future fuel price might be vague. Again, the required annual return the process must yield may often be a rather arbitrary management decision.

The results for these nine cases are summarized in Table 2. In addition, these results are compared with a safe method of analysis which constitutes the method now generally used in industry. This current practice

TABLE 2—Petroleum Distillation Preheat Train Results

Case	Basis	Total Cost M$/Yr.	Optimal Policies mm Btu/Hr.					Principle Stream Temperatures					Auxiliary Stream Temperatures				
		f_6	Q_6	Q_5	Q_4	Q_3	Q_2	T_6	T_5	T_4	T_3	T_2	t_6	t_5	t_4	t_3	t_2
1	Current Practice.....	.....	5.72	11.08	21.60	43.4	6.70	83	121	200	358	382	100	121	200	375	382
2	Note 1.....	207.5	5.54	11.06	21.69	42.0	5.59	80	120	197	350	372	105	119	192	381	425
3	p_F = 20¢/MM Btu.....	317.2	Same Results							Same					Same		
4	p_F = 30¢/MM Btu.....	426.8	Same Results							Same					Same		
5	p_F = 1¢/MM Btu.....	108.6	Same Results							Same					Same		
6	Note 2.....	57.3	5.54	11.06	21.69	42.0	5.59			Same					Same		
7	Yield = 10%.....	32.8	5.54	11.44	21.69	42.0	6.30	80	121	200	353	376	105	110	192	381	402
8	Yield = 50%.....	128.2	5.54	9.15	20.00	33.6	5.34	80	113	186	308	327	105	168	216	314	444
9	Note 3.....	138.4	5.54	9.15	20.00	33.6	9.15	80	113	186	308	342	105	168	216	314	477

Note 1: Base Case. Includes annual cost objective function, LMTD correction factor and p_F = 10¢/MM Btu, p_W = 1¢/M Gals., Yield = 20%, Q_1 = 248 MM Btu/Hr.
Note 2: New Base. Q_1 = 159 MM Btu/Hr. p_F = 1¢/MM Btu, p_W = 1¢/M Gal., Yield = 20%.
Note 3: Heat available for allocation in stage 2 was doubled from 11.82 MM Btu/Hr. to 23.64 MM Btu/Hr.

can be expressed mathematically for the heat allocated to stage j as:

$$Q_j = \text{Min.} \begin{cases} R_j \\ S_j = \dfrac{t_j^\circ - T_{j+1}}{b_j + B} \end{cases} \qquad (18)$$

The second factor S_j is equivalent to $T_j = t_j$, e.g. no temperature cross, for a linear Q-T relationship.

To illustrate the appearance of the optimal policy function, $Q_j(Q^\circ_{j+1})$ was plotted against the condition of the feed to stage j, Q°_{j+1}. In case 2, these policies were rather insensitive to this feed condition (Figure 4). However, the same policies show considerable more variation for case 9 (Figure 5).

Example 2—Reactor Feed To Effluent Exchange. This is an example of a two stage, single decision process as illustrated in Figure 1. As mentioned earlier, this type of problem can be solved quite quickly by repetitive calculations. It was included here simply to emphasize the versatility offered by the DP technique. Thus the computer solved the problem in two to three seconds against two to three hours by hand calculations. Hence, if a general multistage DP was designed mainly for the complex problems as illustrated in Example 1, it would also prove rather useful for the more common and simpler problems.

The results for the data presented in Figure 1 are listed in Table 3.

Some Conclusions. Several conclusions can be drawn from this study, and, even though these tend to be somewhat vague, they should be of some value. These are:

- The present method of obtaining the heat allocation simply by preventing temperature crosses has been shown to be quite a reasonable estimate of the optimal policy. As far as this writer knows, this has never been proved before. This method was most likely accepted based on instinct and judgment of experienced engineers, and also in that it was a convenient means around a tricky problem.
- Although the optimal policies obtained in this study appeared to be somewhat insensitive to many variables, even including the feed condition, there is no reason why this should be the general case. In fact, it would be highly illogical to presume, as some cost factor became larger and larger, that this would never force the optimal policy one way or the other.
- Thus, even though the present method may be a

TABLE 3—Results for Example 2

Case	Method	Optimal Policy MMBtu/Hr.		Outlet Temp. °F	
		Q_2	Q_1	T_2	t_2
1	Equal Outlet Temp....	22.00	38.91	398	398
2	DP Method Yield 20% p_F = 30¢/MM.....	24.78	36.13	435	372

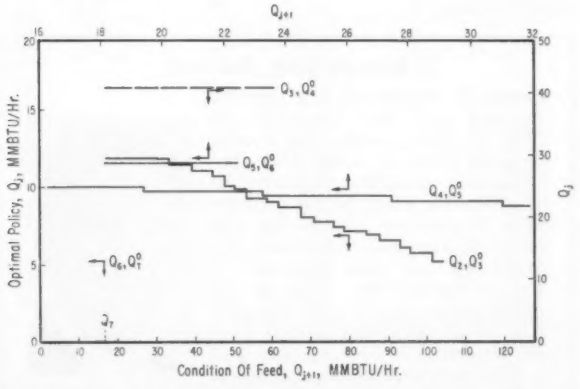


FIGURE 4—The proper choice of exchanger allocation was rather insensitive to the feed condition as shown in Case 2.

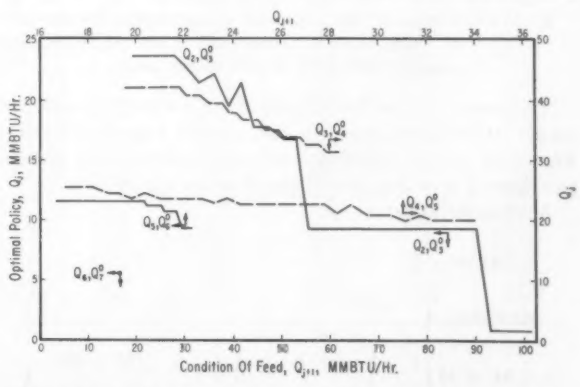


FIGURE 5—In Case 9, feed condition had a greater influence on exchanger allocation.

good approximation, at times it could be woefully inadequate and completely miss some sizeable annual savings.

Additions to the Mathematical Model. The model used here was limited in many ways, since it was desired to keep it fairly simple. Several factors should be considered for a more general study. These would include:

- A design which could be used for either type of heat exchanger train (Case 1 and 2). It should be possible to design a model which also could give the optimal policy for existing heat exchanger trains.
- A more accurate Q-T function for each stream. A linear relationship was used in this study. This function, however, could be defined in a computer memory by a table of Q vs T. This heating curve could then include the effects of temperature on specific heat and percent vaporized.
- Several specific subroutines for the various types of exchangers in use, along with a more precise cost equation for each. This would permit a specification for a shell and tube, double pipe, finned, air cooled, or box cooler at any of the stages.
- A more general subroutine to specify the number of shell passes required, along with the desired equation for F_t.

Another Type of Problem Handled by DP

REPLACEMENT PROBLEMS

In many processes the desired period of operation often far exceeds the life expectancy of some facility. Thus this facility, whether it be a catalyst, filter medium, adsorbent, or any piece of depreciable equipment, must be replaced several times within this period. The problem then is to select the number of replacements to maximize profits realized from the process.

Obviously operating costs rise directly with the frequency of changes. On the other hand, the fewer of these, the older and less efficient will the facility become, and product quality and/or quantity may fall. Thus the multistage decision problem requires that a decision be made, at every sub-period j (such as days) in the life of a facility (years), on whether a replacement should be made.

Roberts[7] has used this technique in a study of catalyst replacement policies. The same type of analysis would also be suitable for replacement of adsorbent in fixed bed adsorbers.[3]

Consider a possible new approach to the familiar equipment replacement problem. We shall cast this problem in the mold of a car replacement process.

Let

$g(M)$ = Cost/mile to drive a car with a current age of M miles. This would include the cost of gas, oil, tires, maintenance, insurance, and depreciation.

$f_N(M)$ = Minimum cost to provide transportation for the next M years, with a present car of age M miles, and expected ΔM miles of driving per year.

The problem can be visualized by picturing some car owner, with M miles on his car, and an expected driving life of N years, deciding each year whether or not to purchase a new car, and if so, of what age M′.

Mathematically:

$$f_N(M) = \underset{0 \leq M' \leq M}{\text{Minimum}} \begin{cases} \text{A. } f_N(M') \\ \text{B. } \displaystyle\int_M^{M+\Delta M} g(m)\,dm + \frac{1}{1+i} f_{N-1}(M+\Delta M) \end{cases} \tag{28}$$

Let $S(M)$ = Salvage value of car at M miles

i = Interest rate

$$f_1(M) = \underset{0 \leq M' \leq M}{\text{Minimum}} \begin{cases} \text{A. } \displaystyle\int_{M'}^{M'+\Delta M} g(m)\,dm - \frac{1}{1+i} S(M'+\Delta M) \\ \text{B. } \displaystyle\int_{M}^{M+\Delta M} g(m)\,dm - \frac{1}{1+i} S(M+\Delta M) \end{cases} \tag{29}$$

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It is a pleasure to acknowledge the guidance and many helpful suggestions of Professor O. Brownlee, Department of Economics, and Professor R. Aris, Department of Chemical Engineering, University of Minnesota, in the conduction of this research.

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Key Words for Indexing

Computations, Computer, Evaporation, Heat Exchangers, Optimization, Replacing, Sizing

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Westbrook

New Charts for Hydrocarbon Vapor-Liquid Equilibria

S. T. Hadden* and H. G. Grayson
Socony Mobil Oil Co., Inc., New York, N. Y.

This article presents extensions, improvements, and a consolidation of the vapor-liquid equilibria correlations of Hadden and Winn, which use convergence pressure as a composition parameter. These extended correlations, which are in nomographic form, apply to light hydrocarbons and petroleum fractions at temperatures from —260° F to 800° F and at pressures up to 10,000 psia, and to certain non-hydrocarbon systems.

Hadden[11, 12, 13] and Winn[39], among others have presented correlations for obtaining phase equilibrium K values for hydrocarbon systems using convergence pressure as a convenient composition parameter. These references adequately describe the bases for such correlations.

Figures 1 and 2 are the primary working charts to relate K to component, temperature, pressure, and convergence pressure. (See note at end of article about availability of larger graphs). Figure 1 is the Winn nomograph[39] with a revised composition scale for methane in light hydrocarbons. Figure 2 is a new chart similar in principle to Figure 1 but for the lower temperature range (down to —260° F).

Figure 3 through 12, containing much new material, are aids in determining the proper convergence pressures (P_{cv}) and convergence pressure factors for determining Ks on Figure 1 and 2.

Table 1 gives improved and extended "volatility exponents"[39] used in determining Ks of TBP, 50° F cuts having atmospheric mid-boiling points between 125° F and 795° F and pure hydrocarbons with normal boiling points between 210° F and 420° F. The "volatility exponent" is simply a geometric factor for extending the boiling point scale on the nomograms.

*Present address: Dow Chemical Co., Midland, Mich.

TABLE 1—Volatility Exponent for Pure Hydrocarbons and True Boiling Point 50° F Cuts at 5° F Intervals on Boiling Point

Temp. Interval, Deg. F	VOLATILITY EXPONENT, b									
	Pure, Hydrocarbons, NBP, °F			50 °F Cuts, TBP Mid-Boiling Point Temperatures, °F						
	200	300	400	100	200	300	400	500	600	700
00	....	0.360	0.834	.....	—0.081	0.326	0.792	1.348	2.016	2.801
05	....	0.381	0.861	.....	—0.061	0.348	0.817	1.379	2.053	2.843
10	0.003	0.403	0.888	.....	—0.041	0.370	0.842	1.410	2.090	2.886
15	0.021	0.425	0.916	.....	—0.021	0.392	0.868	1.441	2.126	2.928
20	0.040	0.447	0.944	.....	—0.002	0.414	0.894	1.472	2.164	2.972
25	0.060	0.469	....	—0.376	0.018	0.436	0.921	1.504	2.202	3.014
30	0.079	0.491	....	—0.356	0.038	0.458	0.948	1.536	2.240	3.058
35	0.098	0.514	....	—0.336	0.058	0.481	0.974	1.569	2.278	3.102
40	0.117	0.537	....	—0.316	0.078	0.504	1.002	1.602	2.316	3.146
45	0.137	0.560	....	—0.296	0.098	0.526	1.029	1.634	2.355	3.190
50	0.156	0.584	....	—0.276	0.118	0.550	1.057	1.668	2.394	3.234
55	0.176	0.607	....	—0.257	0.138	0.572	1.085	1.701	2.434	3.280
60	0.196	0.631	....	—0.237	0.159	0.596	1.113	1.735	2.474	3.324
65	0.216	0.656	....	—0.218	0.180	0.620	1.142	1.769	2.514	3.370
70	0.236	0.680	....	—0.198	0.200	0.644	1.170	1.804	2.554	3.415
75	0.256	0.705	....	—0.178	0.221	0.668	1.199	1.838	2.594	3.461
80	0.277	0.730	....	—0.158	0.242	0.692	1.228	1.874	2.635	3.507
85	0.297	0.756	....	—0.139	0.262	0.716	1.258	1.908	2.676	3.553
90	0.318	0.781	....	—0.120	0.284	0.742	1.288	1.944	2.718	3.600
95	0.339	0.808	....	—0.100	0.305	0.766	1.318	1.980	2.759	3.646

$$K_H = K_7 \Big/ \left(\frac{K_2}{K_7}\right)^b$$

Where: K_H = K Value of the cut or high boiling pure hydrocarbon.
K_2 = K Value of ethane at the temperature, pressure and convergence pressure of the system.
K_7 = K Value of n-heptane at the temperature, pressure and convergence pressure of the system.
b = Volatility exponent from table 1.

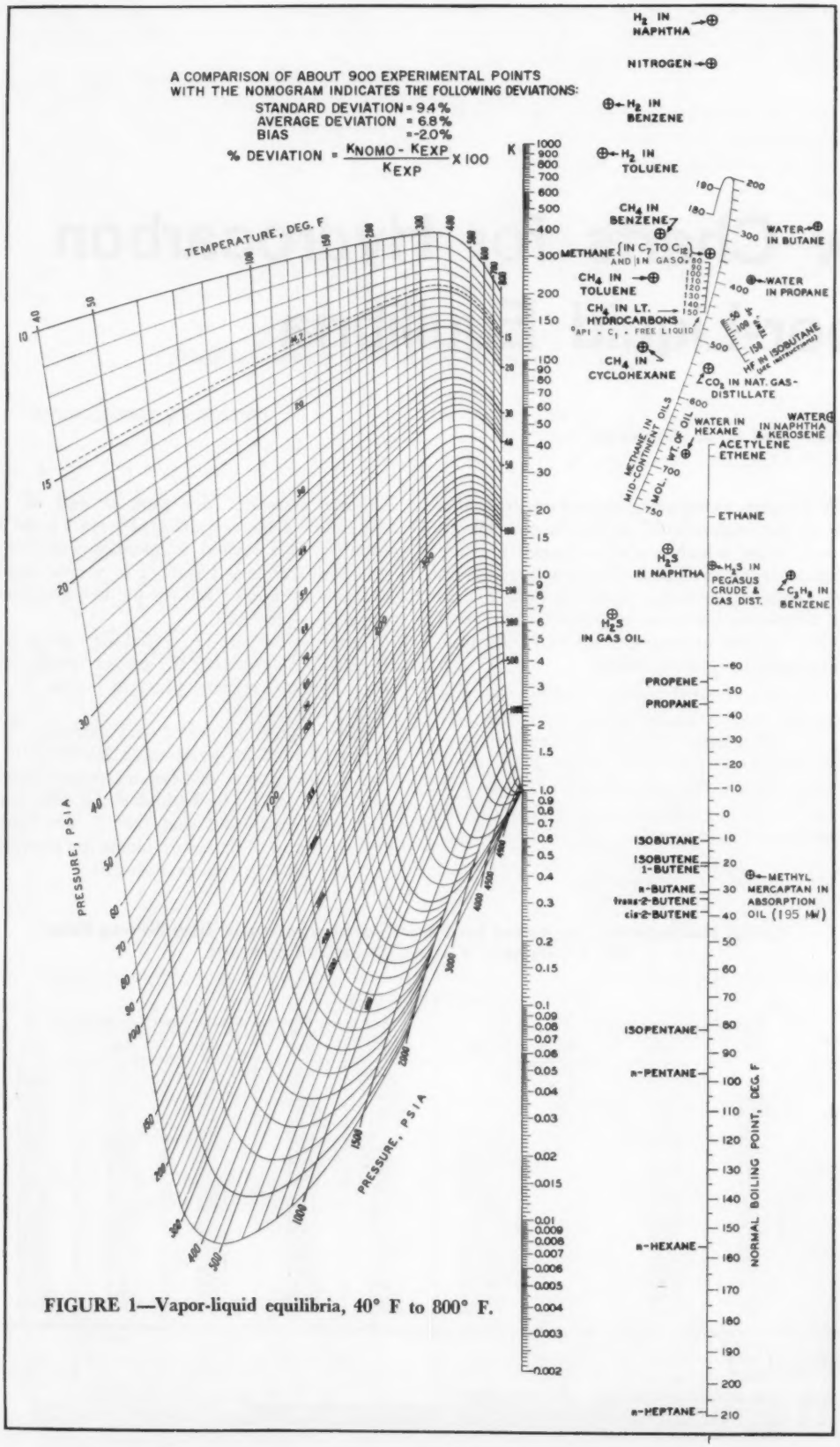


FIGURE 1—Vapor-liquid equilibria, 40° F to 800° F.

A summary of the deviations between experimental K values and those derived from the correlations is given in Table 2.

TABLE 2

Systems Applicable	No. of Exp. Pts.	% Deviation Arith. Avg.	Standard	Bias
To Fig. 1	965	± 6.8	± 9.4	—2.0
To Fig. 2	604	± 6.2	± 8.8	—0.1
To Table 2	377	± 7.1	± 10.3	+2.4

The deviations and source data for the low temperature systems upon which the new K chart, Figure 2, is based are detailed in Table 3.

SYSTEMS TO WHICH THESE K CORRELATIONS APPLY

1. Mixtures of paraffins and/or olefins.

2. Mixtures of aromatic hydrocarbons up to about 150 psia. The normal boiling points of the aromatic components are used to define the component points on the component scale of Figure 1 and 2. In effect, the K correlations presented here apply to systems where the liquid phase can be considered ideal, i.e. the activity coefficient is equal to 1.0. Where the liquid phase is far from being ideal, as for aromatic-paraffin mixtures, the K values obtained from the correlations should be multiplied by appropriate activity coefficients. Myers,[22] NGAA,[24] and Prausnitz, Edmister and Chao,[27] among others, present means of obtaining activity coefficients.

3. Special Mixtures:

A. *Methane*

The K value of methane varies not only with the temperature, pressure and convergence pressure of the system but also with the character of the solvent. Therefore, special component points are shown for methane in toluene, in benzene, in cyclohexane, in light hydrocarbons, in gasoline and in Mid-Continent oils. For methane in equilibrium with light hydrocarbons the component point is fixed by the °API gravity of the liquid phase exclusive of methane. A point along the line of methane in Mid-Continent oils, positioned at the molecular weight of the oil, may be used for methane in equilibrium with absorber oils, gas oils, or crude oils having a UOP characterization factor of about 11.8.

B. *Hydrogen*

The K values of hydrogen in toluene, benzene, and naphtha can be estimated by using the component points on Figure 1 for these mixtures. These points should be used only for systems operating below 200 psia, by using the operating temperature and pressure as the pivot point on the nomogram. Above 200 psia, and especially above 1000 psia, serious deviations can result from use of the nomogram for hydrogen systems. The K values for hydrocarbons in hydrogen systems are generally considerably lower than would be determined from Figures 1 or 2. Correlations that are specific for hydrogen-hydrocarbon systems include Chao and Seader,[5] Prausnitz and Duffin,[28] and Lenoir and Hipkin.[19]

Practically speaking, however, the hydrogen correlations presented here have been used for catalytic reformer system design at pressures up to 600 psia. The hydrogen-light hydrocarbon-gasoline mixtures encountered in the reformer process are relatively insensitive to large errors in K. The relative volatility between hydrogen and the average hydrocarbon is so great that although the absolute values of the Ks may be in error, their effect on the equilibrium flash is only minor. Or expressing it another way, there are certain systems of the so-called "dumb-bell" type, i.e., mixtures containing a light hydrocarbon and a heavy hydrocarbon with very little in between, which are relatively insensitive to temperature and changes in K. For such systems an estimate of K is generally sufficient.

For calculations involving hydrogen enrichment and sharp fractionation, use the correlations mentioned above that are specific for hydrogen-hydrocarbon mixtures.

C. *Hydrogen Fluoride*

The component position for HF in isobutane is indicated by a short line graduated with the temperature of the system. The nomogram is applicable to this system from 40° F to 160° F and up to 200 lbs. pressure without consideration of convergence pressure, with a standard deviation of 3 percent based on a comparison of 15 points. It is applicable under conditions where the vapor phase coexists with two liquid phases (the hydrocarbon rich liquid phase and the HF rich liquid phase). It is also applicable where the vapor phase coexists only with a hydrocarbon rich liquid phase. In either case the K of HF is the ratio of its molal concentration in the vapor phase to its molal concentration in the hydrocarbon rich liquid phase.

D. *Carbon Dioxide*

The component point for carbon dioxide in a natural gas plus condensate system is indicated. This system had a convergence pressure of about 5,000 psia for temperatures between 100° F and 250° F. This component point can be used to estimate the K of CO_2 in wide-boiling range multicomponent systems.

E. *Hydrogen Sulfide*

Component points for hydrogen sulfide in a gas oil, in naphtha, and in a mixture of Pegasus

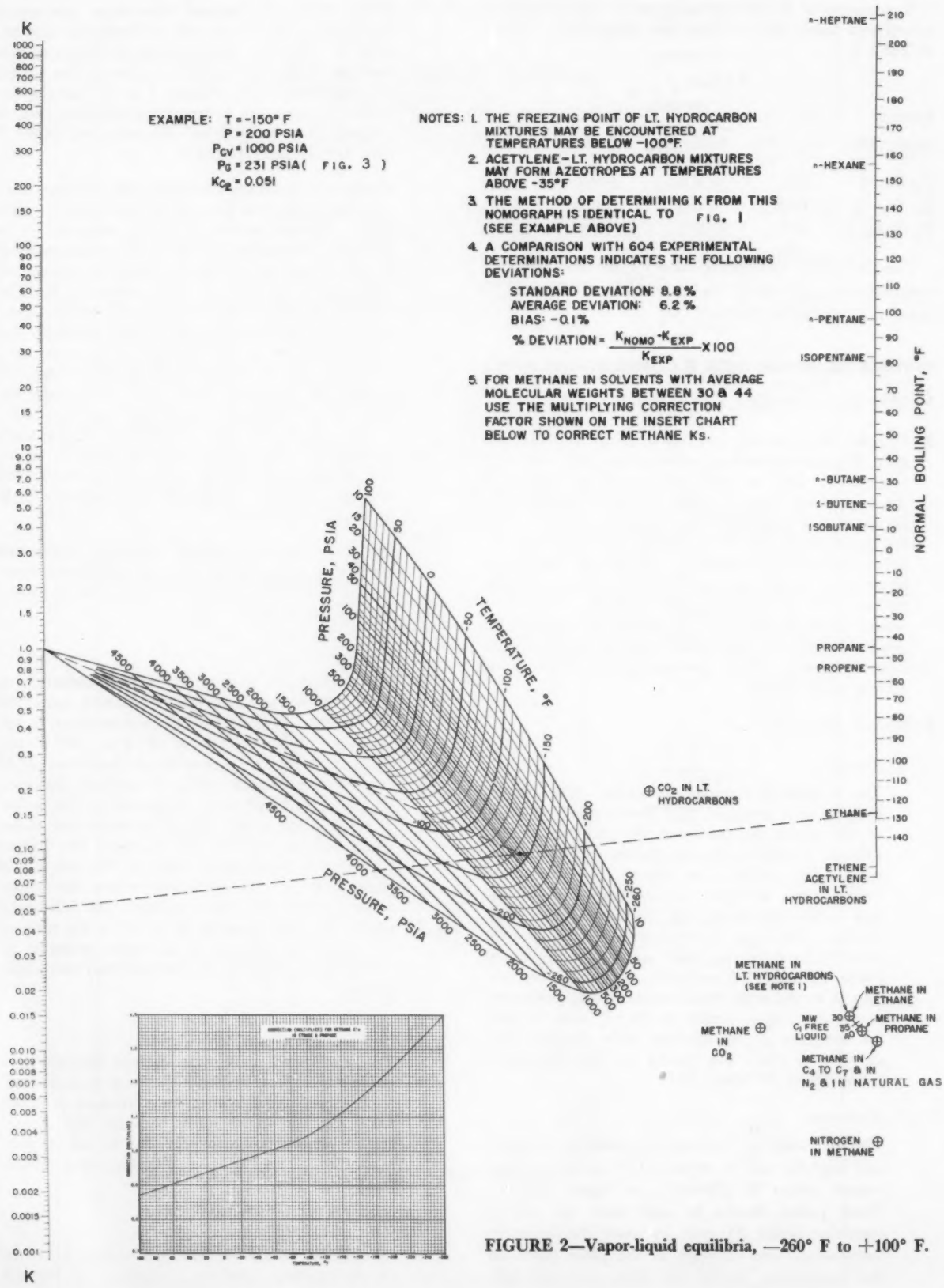

K
EXAMPLE: T = -150° F
P = 200 PSIA
P_{CV} = 1000 PSIA
P_G = 231 PSIA (FIG. 3)
K_{C_2} = 0.051
NOTES: 1. THE FREEZING POINT OF LT. HYDROCARBON MIXTURES MAY BE ENCOUNTERED AT TEMPERATURES BELOW -100°F.
2. ACETYLENE-LT. HYDROCARBON MIXTURES MAY FORM AZEOTROPES AT TEMPERATURES ABOVE -35°F
3. THE METHOD OF DETERMINING K FROM THIS NOMOGRAPH IS IDENTICAL TO FIG. 1 (SEE EXAMPLE ABOVE)
4. A COMPARISON WITH 604 EXPERIMENTAL DETERMINATIONS INDICATES THE FOLLOWING DEVIATIONS:
STANDARD DEVIATION: 8.8%
AVERAGE DEVIATION: 6.2%
BIAS: -0.1%
% DEVIATION = $\frac{K_{NOMO} - K_{EXP}}{K_{EXP}} \times 100$
5. FOR METHANE IN SOLVENTS WITH AVERAGE MOLECULAR WEIGHTS BETWEEN 30 & 44 USE THE MULTIPLYING CORRECTION FACTOR SHOWN ON THE INSERT CHART BELOW TO CORRECT METHANE Ks.
PRESSURE, PSIA
TEMPERATURE, °F
PRESSURE, PSIA
⊕ CO_2 IN LT. HYDROCARBONS
n-HEPTANE
n-HEXANE
n-PENTANE
ISOPENTANE
n-BUTANE
1-BUTENE
ISOBUTANE
PROPANE
PROPENE
ETHANE
ETHENE
ACETYLENE IN LT. HYDROCARBONS
NORMAL BOILING POINT, °F
METHANE IN LT. HYDROCARBONS (SEE NOTE 1)
METHANE IN ETHANE
METHANE IN PROPANE
MW C_1 FREE LIQUID
METHANE ⊕ IN CO_2
METHANE IN C_4 TO C_7 & IN N_2 & IN NATURAL GAS
NITROGEN ⊕ IN METHANE
K

FIGURE 2—Vapor-liquid equilibria, —260° F to +100° F.

crude and a natural gas distillate are indicated on the nomogram. The data used to establish the naphtha and gas oil points were at ambient temperature and at pressures from 50 to 200 psia. Those for the mixture of Pegasus crude and natural gas distillate were from 40° F to 250° F and 50 to 4000 psia. The convergence pressure used to establish these points was 5000 psia. Data for hydrogen sulfide in ethane and propane have not been included on the nomogram because of azeotrope formation.

F. *Methyl Mercaptan*

A point for methyl mercaptan in a 195 molecular weight absorption oil is located on the nomogram. The conditions used to establish the point ranged from 65° F to 79° F and from 67 to 605 psia.

G. *Water*

Component points for water in propane, in butane, in hexane, and in a naphtha are indicated on the nomogram. The convergence pressure to be used for these water systems is the sum of the critical pressure of the hydrocarbon and the vapor pressure of water at the critical temperature of the hydrocarbon. As with the HF-isobutane system, it is applicable under conditions where the hydrocarbon rich liquid phase exists either with or without the other liquid phase.

Additional special component points can be added to the nomogram by using data at several temperatures and pressures. Temporary construction lines through the K scale and the temperature, pressure grid may be used to establish the component point from which K values at other temperatures and pressures may be estimated.

If specific experimental data for the system of interest is available, it should be used in preference to any generalized correlation. This is especially true for close boiling hydrocarbon mixtures and for temperatures below the critical temperature of the lightest component in the liquid for pressures above 150 psia.

TABLE 3—Summary of Deviations for Systems Applicable to Figure 2

System	Ref.	Temp. °F	Press. psia	No. of Pts.	Std. Dev. Percent	Average Percent	Bias Percent
Methane in							
Ethane	(4) (29)	+ 80 to —200	100— 900	65	5.3	3.8	—0.3
Propane	(1) (29)	+ 50 to —200	100—1400	73	6.5	4.3	+0.2
n-Butane	(23)	+100 to — 6	147— 441	8	6.8	5.8	—4.4
Multicomp.	(8) (29) (36)	50 to —238	100—1300	62	9.1	6.4	—1.5
CO_2	(9)	+ 29 to — 83	300—1000	18	17.3	12.6	+2.9
N_2	(3)	—130 to —200	200— 600	24	5.6	4.6	+0.9
				250	8.1	5.4	—0.2
Ethane in							
Methane	(4) (29)	+ 80 to —200	100— 900	63	9.2	6.1	—2.0
Ethylene	(14)	+ 40 to — 35	150— 465	8	2.1	1.6	+0.8
Propylene	(21)	+ 40 to + 10	100— 350	9	2.0	1.6	+1.0
Propane	(29)	+ 50 to 0	100— 400	5	8.6	8.3	+8.3
Multicomp.	(8) (29) (36)	+ 50 to —169	100—1200	55	9.7	7.7	+2.4
Acetylene	(14)	+ 40 to 0	240— 465	3	1.8	1.6	+1.6
				143	8.8	6.2	+0.5
Propane in							
Methane	(1) (29)	+ 50 to —109	100—1300	57	11.1	8.3	—1.1
Ethane	(29)	+ 50 to 0	100— 400	5	6.5	5.4	—5.1
Multicomp.	(8) (29)	+ 50 to —100	100—1200	37	7.4	5.9	+0.5
CO_2	(2)	+ 32 to — 40	50— 300	7	13.9	10.3	—8.5
				106	10.0	7.5	—1.2
N-Butane in							
Methane	(23)	+100 to — 6	147— 441	9	11.9	9.5	—8.6
Multicomp.	(8)	+ 20 to — 60	100— 497	9	7.2	6.1	—0.6
				18	9.9	7.8	—4.6
N-Pentane in							
Multicomp.	(8)	+ 20	102— 204	2	5.4	5.3	+0.8
				2	5.4	5.3	+0.8
Ethylene in							
Ethane	(14)	+ 40 to — 35	150— 465	9	3.6	3.2	+1.9
Ethane-Acety	(14)	+ 40 to — 35	150— 465	15	5.5	4.4	+2.3
				24	4.9	3.9	+2.1
Propylene in							
Ethane	(21)	+ 40 to + 10	100— 300	8	8.7	6.1	+5.3
				8	8.7	6.1	+5.3
Nitrogen in							
Methane	(3)	—140 to —200	200— 500	18	7.2	6.0	—1.4
Natural Gas	(36)	—130 to —235	100	8	10.3	8.5	+3.4
				26	8.3	6.8	+0.1
CO_2 in							
Methane	(9)	+ 29 to — 83	300—1000	18	9.8	7.2	+4.2
Propane	(2)	+ 32 to — 40	50— 400	9	13.3	9.5	+7.6
				27	11.1	8.0	+5.3
GRAND TOTAL				604	8.8	6.2	—0.1

$$\% \text{ Deviation} = \left[\frac{K_{nomo} - K_{exp}}{K_{exp}}\right] \times 100$$

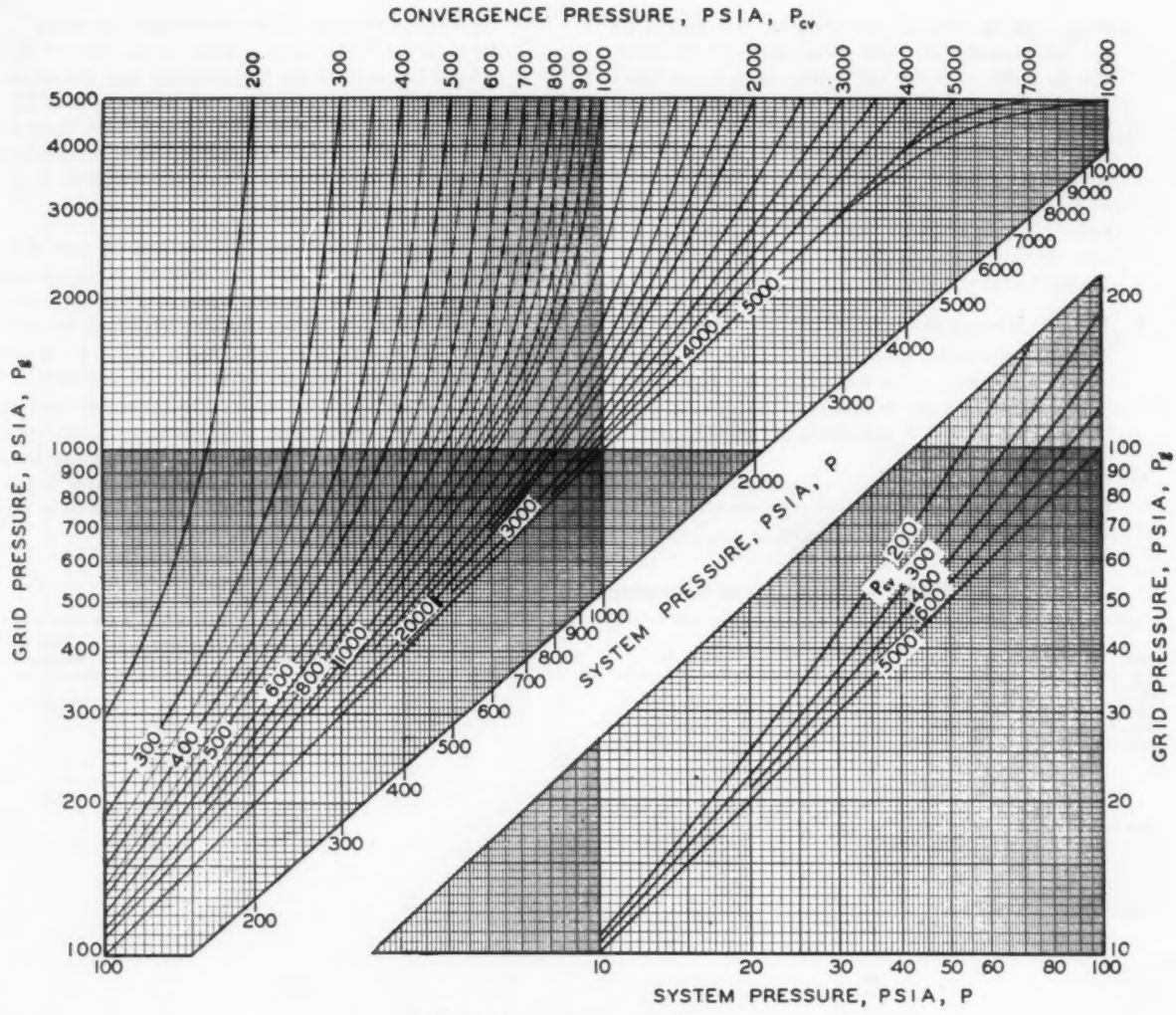

CONVERGENCE PRESSURE, PSIA, P_{cv}
GRID PRESSURE, PSIA, P_g
SYSTEM PRESSURE, PSIA, P
SYSTEM PRESSURE, PSIA, P
GRID PRESSURE, PSIA, P_g

FIGURE 3—Grid pressure relationship.

HOW TO USE NOMOGRAMS

To use the K nomograms, a P, T pivot point for the temperature-pressure grid must first be determined. This pivot point is a function of the operating pressure and temperature and of the liquid composition parameter, convergence pressure (P_{cv}).

At a given temperature the over-all effect of liquid composition on convergence pressure is influenced predominantly by: (1) the identity of the lightest component and, (2) the spread between the critical temperatures of the lightest component and the critical temperature of the mixture excluding the lightest component (the "average heavy" component).

The "lightest component" for P_{cv} purposes is the lightest component having at least 0.001 mole fraction concentration in the liquid phase.

If the operating temperature is below the critical temperature of the lightest component, use the critical pressure of the lightest component as the system convergence pressure.

Short Method for Approximating P_{cv}

Figure 5 is used for a quick approximation of P_{cv} for mixtures readily defined. For a mixture that does not correspond to one on Figure 5, the P_{cv} is estimated from the critical loci curves on Figures 6 and 12. The curve to be used is one that has a low temperature terminal that corresponds to the lightest component in the mixture and has a high temperature terminal that corresponds to the "average heavy" component in the given mixture.

If the "average heavy" component falls between two components on the indexes, the line for the heavier of the two components is used. In choosing the range of the "average heavy component," disregard the heaviest components which together sum to less than 2 mole percent of the liquid.

Table 4 presents the references for the experimental data upon which Figures 5 through 12 are based.

Examples 1 through 3 below are illustrative of the short cut method of estimating convergence pressure.

TABLE 4—References for Convergence Pressure Charts

(Figures 5 Through 12)

System		Author	Reference
Methane	— ethane	Bloomer; Ruhemann	(4) (31)
	— propane	Sage, Lacey & Schaafsma	(34)
	— isobutane	Olds, Sage & Lacey	(26)
	— butane	Sage, Hicks & Lacey	(32)
	— n-pentane	Sage, Reamer, Olds, & Lacey	(35)
Ethylene	— butane	Williams	(38)
	— n-heptane	Kay	(18)
Ethane	— propylene	Lu, Newitt & Ruhemann	(20)
	— n-butane	Kay	(16)
	— n-heptane	Kay	(15)
Propylene	— isobutylene	Goff, Farrington & Sage	(10)
Propane	— n-butane	Nysewander, Sage & Lacey	(25)
	— isopentane	Vaughn & Collins	(37)
	— n-pentane	Sage & Lacey	(33)
Butane	— hexane	Cummings	(6)
	— heptane	Kay	(17)
Pentane	— heptane	Cummings, Stone & Volante	(7)
Hexane	— octane	Cummings	(6)

Example 3 also illustrates the method of discarding trace components.

Estimate the average heavy component in the following mixtures.

Example 1:

Equivalent boiling range of mixture: $C_1 - C_{10}$

Lt. Component: C_1

Avg. Hvy. Component: $\frac{C_2 + C_{10}}{2} = C_6$

Example 2:

Equivalent boiling range of mixture: $C_3 + C_9$

Lt. Component: C_3

Avg. Hvy. Component: $\frac{C_4 + C_9}{2} = C_{6\frac{1}{2}}$, use C_7

Example 3: Short Cut Method of Estimating Average Heavy Component and Method of Discarding Trace Components.

COMPONENT No. C	COMPONENT Name	Reflux Drum—Liquid Mol Fraction		Reboiler—Bottoms Mol Fraction	
	Hydrogen	0.0009	Negligible	0.17×10^{-14}	
1	Methane	0.018	Lt. Compt.	0.67×10^{-14}	
2	Ethane	0.051		0.43×10^{-5}	Negligible
3	Propane	0.080		0.61×10^{-4}	
4	Butane	0.274	Avg. Heavy	0.009	Lt. Compt.
5	Pentane	0.363	Compt.	0.049	
6	Hexane	0.168		0.130 (1)	
7	Heptane	0.045		0.186	Avg. Heavy
8(2)	"225"	0.21×10^{-4} (1)		0.188	Compt.
9(2)	"275"	0.16×10^{-6}		0.103	
10(2)	"335"	0.32×10^{-22}	Negligible	0.083	
11(2)	"375"	0.17×10^{-23}		0.252	
Total		1.000 ±		1.000 ±	
(1) From Typical Electronic Computer Tray-Tray Results.		Avg. Hvy. Compt. = $\frac{C_2 + C_7}{2} = C_{4-1/2}$ Use C_5		Avg. Hvy. Compt. = $\frac{C_5 + C_{11}}{2} = C_8$	
(2) Approx. No. of Carbon Atoms.					

Requirements for K Nomogram Corrections—Figure 4

The significance of convergence pressure for adjusting the K values determined from Figures 1 and 2 is indicated on Figure 4 from the relation between the operating pressure and the estimated convergence pressure. Most of the systems encountered will fall in areas "A", "B", or "C" of Figure 4 requiring only an approximate P_{cv}. For a point falling in area "A", the adjustment for convergence pressure can be neglected, and the operating pressure and temperature are used as the pivot on the K nomograms. For a point falling outside area "A", the effect of convergence pressure is important, and the pivot point must be determined with greater accuracy. For areas "B" and "C" the operating pressure and the approximate convergence pressure are used to determine a grid pressure on Figure 3. For area "B" the operating temperature-pressure point on the nomogram is connected by a straight line to the $K = 1$ point on the K scale, and the pivot point is spotted on this line at the grid pressure. For area "C" the operating temperature and the grid pressure are used as the pivot on the K nomograms. For area "D" the convergence pressure should be determined by a detailed procedure given in the literature.[13]

Use of Nomograms for Systems Falling in Area "A" of Figure 4

Procedure:

A. Estimate P_{cv} from Figure 5 or Figures 6 to 12.

B. Check Figure 4 for area.

C. If in area "A" proceed as follows:

a. Locate the point on the temperature-pressure grid corresponding to the operating temperature and pressure.

b. Lay the hair line of a nomogram reader through this point and through the point on the component

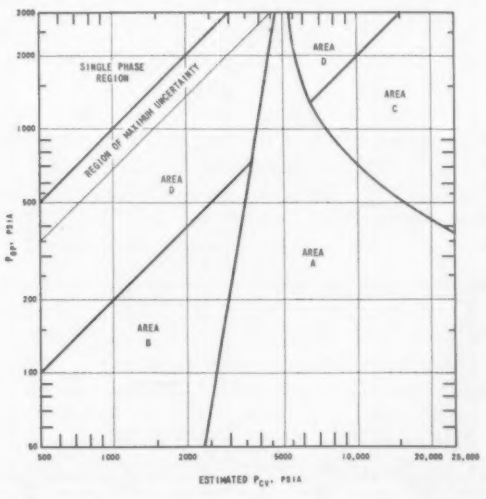


FIGURE 4—Requirements for "K" nomogram corrections based on P_{CV} and P_{OP}.

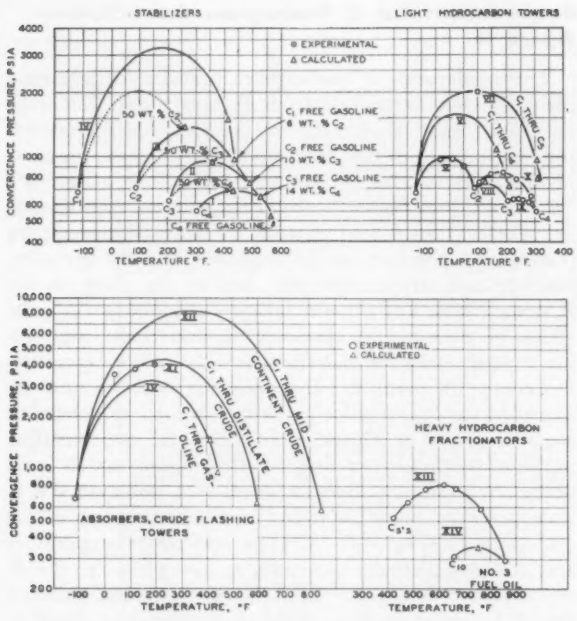


FIGURE 5—Convergence pressure data for typical refinery mixtures.

scale corresponding to the component (or through the normal boiling point of the component, if the component is not shown on the scale).

c. Read the K value at the point of intersection of the hair line with the K scale.

d. On the low temperature nomogram, Figure 2, for methane in ethane and propane, multiply the methane nomogram K by the correction indicated on the inserted chart.

Example 4:

(a) What is the K value for methane in an unstabilized gasoline at 100° F and 200 psia?

Answer: From Curve IV, Figure 5, the convergence pressure is about 3000 psia. On Figure 4 the combination of operating and convergence pressure falls in area "A". Hence, read K directly on Figure 1 for operating T & P. The result is 14.7. (See sketch below).

(b) What is the K value at 100° F and 200 psia for a component of the gasoline in Example (1a) having a boiling point of 190° F?

Answer: As determined in Example (1a) the K can be read directly on Figure 1. The result is 0.0188. (See sketch top Page 215).

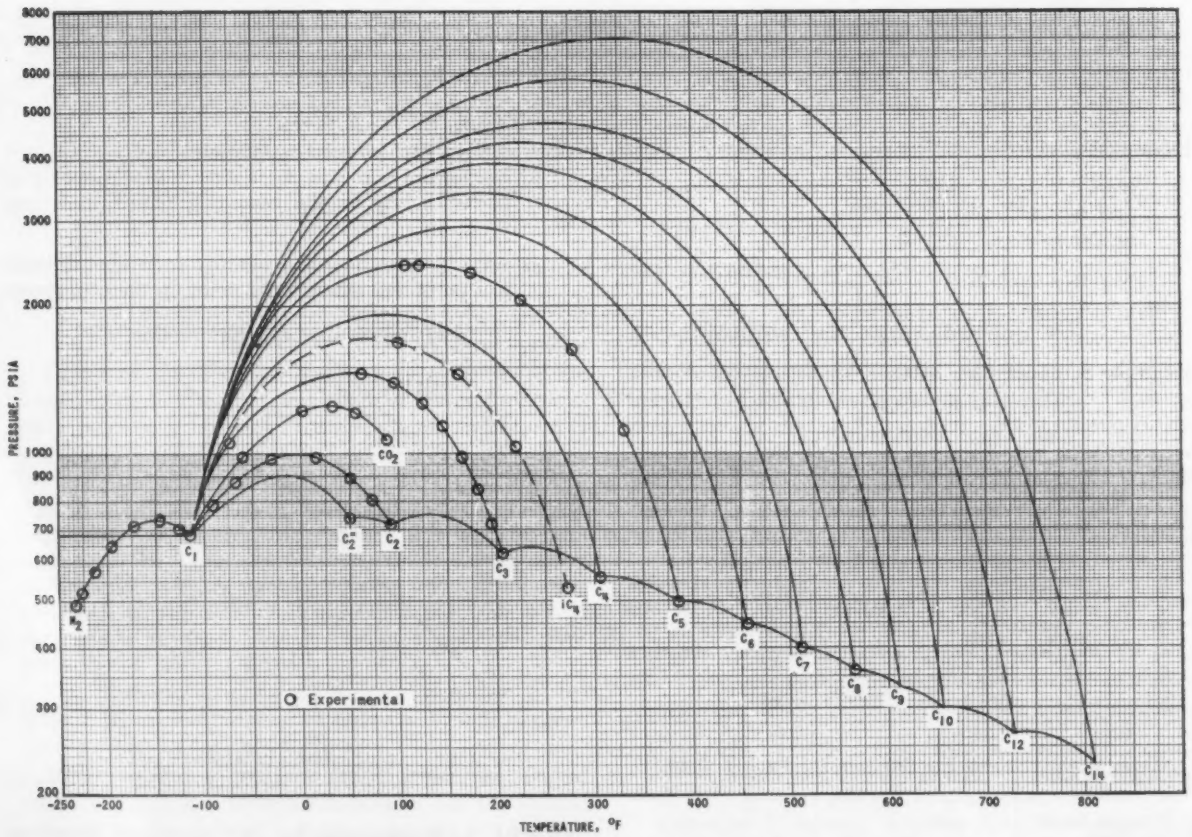
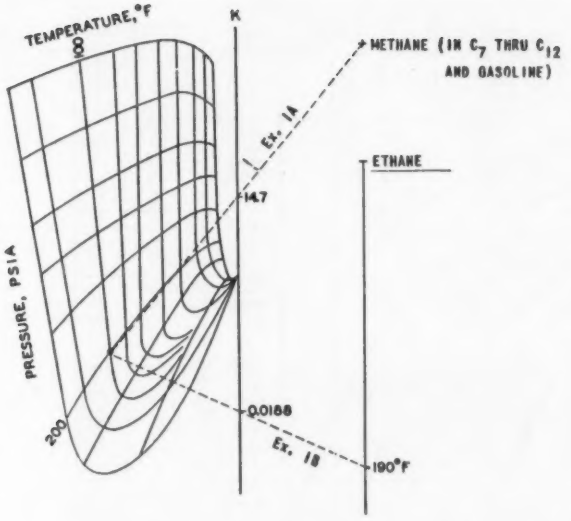


FIGURE 6—Convergence pressure data—methane lightest component.



(c) What is the K value at 500° F and 100 psia for *n*-decane in Mid-Continent crude containing methane as the lightest component?

Answer: From Curve XII, Figure 5, the convergence pressure is about 7,000 psia at 500° F, so that on Figure 4 the point for the operating and convergence pressure falls in area "A." Hence, no P_{cv} correction is required in determining K. Since the normal boiling point of n-decane is above 210° F, the K for n-decane has to be computed from the Ks for ethane (K_2) and heptane (K_7) determined on Figure 1. These values, together with the volatility "b" from Table I, are used to determine the K for n-decane in the expression:

$$K_h = K_7 \Big/ \left(\frac{K_2}{K_7}\right)^b \qquad \text{Equation 1}$$

From Figure 1, $K_2 = 19.3$ and $K_7 = 2.40$ at 500° and 100 psia. From Table 1, b = 0.560 at the NBP of 345° for n-decane (pure hydrocarbon).

$$K = 2.40 \Big/ \left(\frac{19.3}{2.40}\right)^{0.56} = 0.745$$

(d) What is the K value for the 700° F mid-boiling point fraction with the other circumstances the same as in Example (1c)? As the same system and conditions prevail as for Example (1c), the only change is for the volatility exponent "b" (K_2 and K_7 are the same).

Answer: From Table 1, "b" = 2.801

$$K = 2.40 \Big/ \left(\frac{19.3}{2.40}\right)^{2.801} = 0.0070$$

Use of Nomograms for Systems Falling in Area "B" of Figure 4

Procedure:

A. Estimate P_{cv} from Figure 5 or Figures 6 to 12.

B. Check Figure 4 for area.

C. If in area "B", proceed as follows:

a. Determine grid pressure from Figure 3 for the estimated P_{cv} and operating pressure.

b. Locate the point on the temperature-pressure grid (Figure 1 or 2) corresponding to the temperature and pressure of operation.

c. Connect the temperature-pressure point to the K = 1.00 point.

d. Spot the point on this line where it is crossed by the pressure equal to the grid pressure.

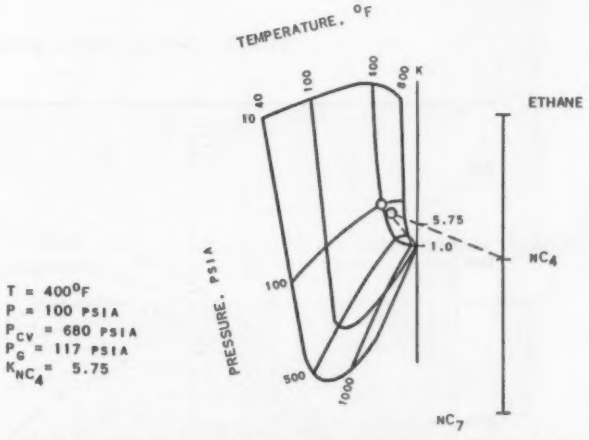
e. Lay the hair line of a nomograph reader through this grid point and the point on the component scale corresponding to the component.

f. Read the K value at the point of intersection of hair line with the K scale.

Example 5:

(a) What is the K value at 400° F and 100 psia for n-butane in a depropanized 400° E.P. gasoline system?

Answer: Estimated P_{cv} is 680 psia from Curve 1, Figure 5. The combination of operating and convergence pressure falls in area "B" on Figure 4. Hence, a grid pressure correction is required before reading K. On Figure 3, a grid pressure of 117 psia is read as the ordinate for the given operating and convergence pressure. Following procedure outlined above, $K_{nC_4} = 5.75$. (See sketch below).



(b) Compute the reboiler temperature of a gasoline stabilizer operating at 165 psia. The composition of the gasoline is shown in the tabulation below: (Assume that the gasoline has properties similar to those on Figure 5 for stabilizers.)

Answer: For the first trial assume the reboiler temperature is 350° F. The lightest component is propane. The estimated convergence pressure is 900 psia (from the propane-gasoline critical locus Figure 5, Curve II). This system falls into area "B" of Figure 4. Therefore, a grid correction is required. From Figure 3 the grid pressure is 193 psia. Using the determined grid point on Figure 1, as outlined above, and "b's" from Table I, the appropriate K value are obtained as listed in the following tabulation.

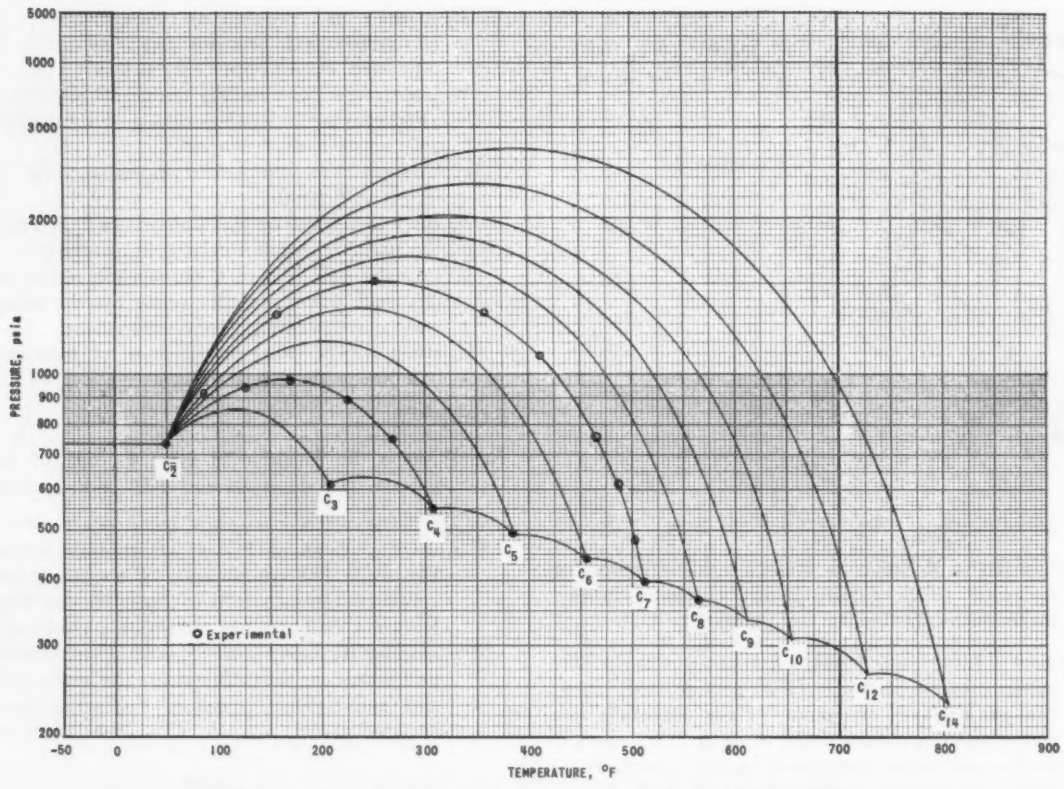


FIGURE 7—Convergence pressure data—ethene lightest component.

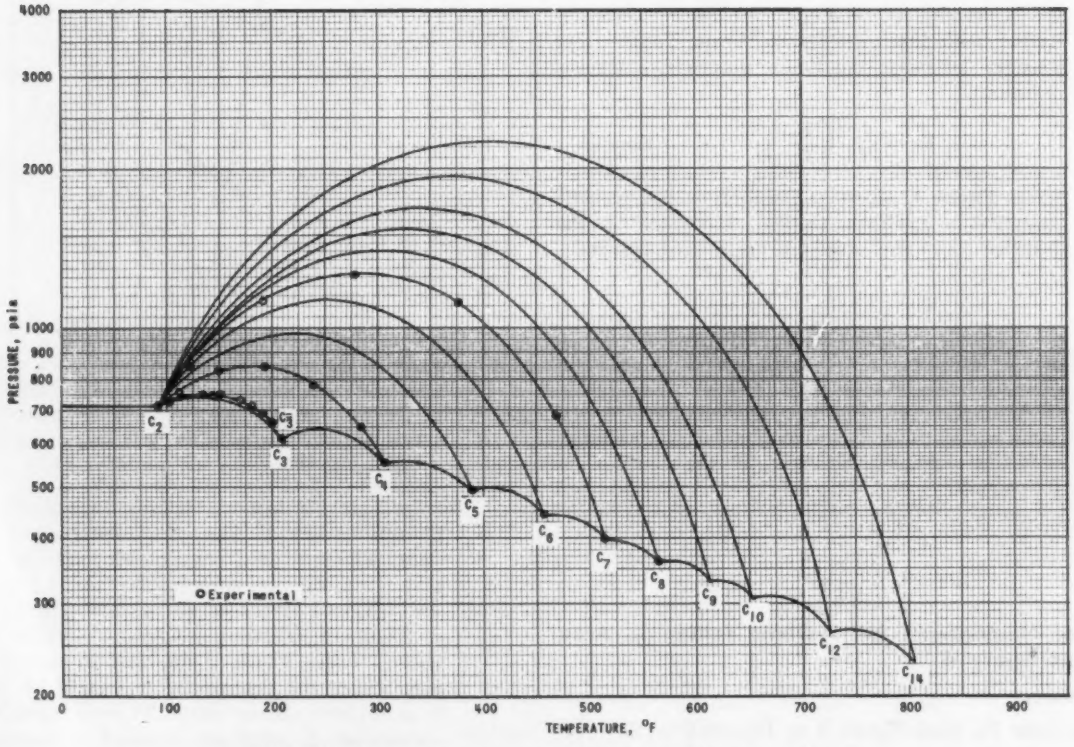


FIGURE 8—Convergence pressure data—ethane lightest component.

Comp.	Gasoline Moles	"b"	K @ 350 °F 165-Pop, 193 P_z	(Moles) X (K)
C_3	50	....	5.30	260
nC_4	1,820	....	3.05	5,550
nC_5	4,320	....	1.75	7,560
nC_6	6,160	....	1.04	6,410
nC_7	3,500	....	0.620	2,170
235 (1)	2,500	0.058	0.529 (2)	1,320
285 (1)	2,200	0.263	0.303 (2)	670
335 (1)	2,160	0.481	0.168 (2)	360
385 (1)	1,280	0.717	0.0883 (2)	110
	23,990			24,410

Notes: (1) Mid-boiling point of a petroleum fraction having a 50° F boiling range.
(2) Calculated from equation (1) using $K_2 = 9.40$ and $K_7 = 0.620$, using the pivot point for this problem.
In this computation since the summation (mole) x (K) is greater than the moles of gasoline, a slightly lower temperature would be used in the next trial.

(c) What are the K values for methane and ethane at —100° F and psia in a methane-ethane system?

Answer: The P_{cv} from Figure 6 is 750 psia. The combination of operating and convergence pressure falls in area "B" on Figure 4. Hence, the grid pressure correction is required before reading K. On Figure 3 a grid pressure of 115 psia is read. Following procedure outlined above and using Figure 2

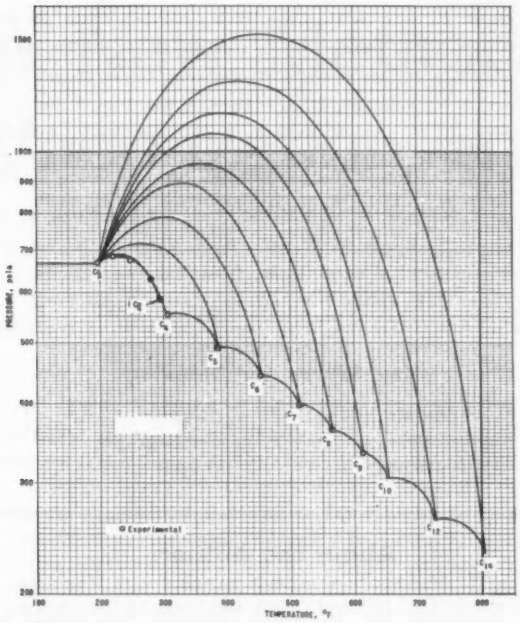


FIGURE 9—Convergence pressure data—propene lightest component.

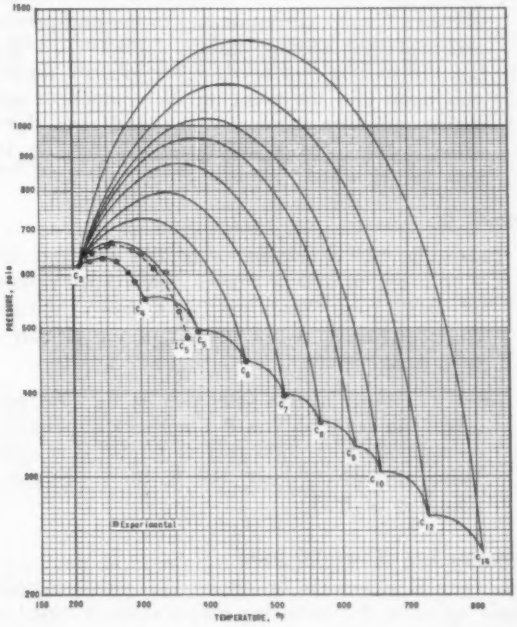


FIGURE 10—Convergence pressure data—propane lightest component.

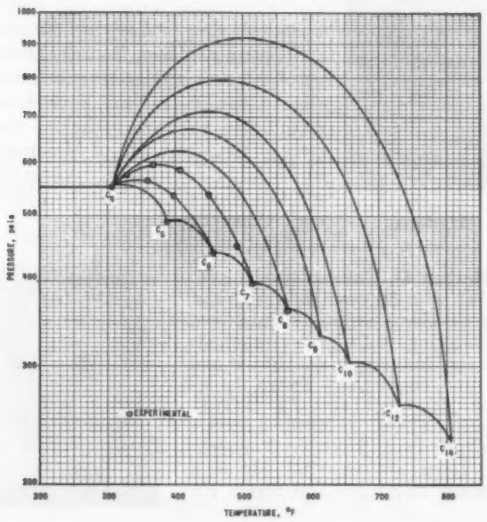


FIGURE 11—Convergence pressure data—n-butane lightest component.

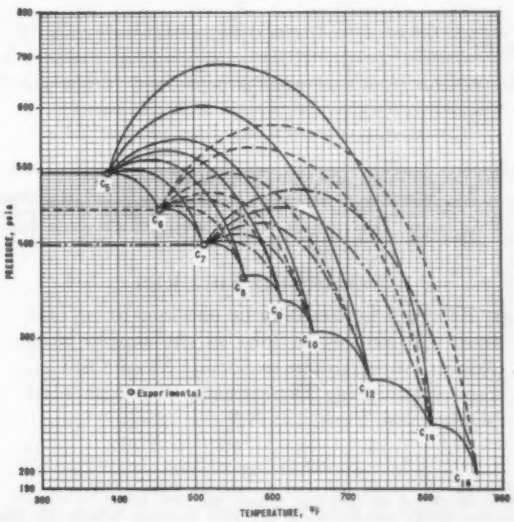


FIGURE 12—Convergence pressure data—pentane, hexane, and heptane.

Methane K = 6.20 (1.047) * = 6.49
Ethane K = 0.337

* Correction factor for methane

Use of Nomograms for Area "C" of Figure 4

(Convergence Pressures Above 5,000 psia)

Procedure:

A. Estimate P_{cv} from Figure 5 or Figures 6 to 12.
B. Check Figure 4 for area.
C. If in area "C", proceed as follows:
   a. Determine grid pressure from Figure 3 for the estimated P_{cv} and operating pressure.
   b. Locate the point on the temperature-pressure grid (Figures 1 or 2) corresponding to the *grid* pressure and the operating temperature.
   c. Lay the hair line of a nomogram reader through this point and the point on the component scale corresponding to the component and read the K value at the point of intersection of the hair line with the K scale.

Example 6:

(a) Determine "K" of n-pentane at 6000 psia and 100° F in a system with a known convergence pressure of 10,000 psia. (Since the P_{cv} is known, the area chart, Figure 4, is not used, and the K can be calculated directly.)

Answer: Figure 3 gives 4600 psia as the grid pressure. The point on the P-T network on Figure 1 corresponding to 4600 psia and 100° F is noted. Using this pivot point, the K for n-pentane is found to be 0.53.

Pressures Less Than 10 psia

Equilibrium K values can be obtained for pressures below 10 psia by using the following simple relation based on Raoult's law.

$$K_a = \frac{10\,K_{10}}{P_a}$$

Where:

K_a = K for given component at pressure < 10 psia and T
K_{10} = K for given component at 10 psia and T
P_a = operating pressure, less than 10 psia

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ENLARGED FIGURES

Enlarged figures may be obtained at no cost from the authors as long as the supply lasts. Address your request to Socony Mobil Oil Co., Inc., Engineering Department, 150 East 42nd Street, New York, 17, N.Y.

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Key Words for Indexing

Convergence
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Liquid
Nomograph
Vapor

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Grayson

A New Method for Equilibrium Vaporization and Condensation

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This is a better method for determining the operating conditions of both flash chambers (for separating multi-component mixtures) and partial equilibrium condensers.

For a specified temperature and pressure, the fraction of the feed in the vapor, ρ, is to be determined. This involves the formulation of multi-component vapor-liquid equilibrium relationships from which ρ may be computed. In conventional methods ρ is first assumed and then calculated by an appropriate summation. This procedure is repeated until the calculated value is equal to the assumed one.[1] Either trial and error or some method of convergence may be used. In this article, an n–1st degree polynomial in ρ is derived for an n component system. ρ is readily determined by solving the polynomial for the root that lies between zero and one. The formulation of the equation is quite systematic and consequently the equation is readily written. The only restriction to the formulation of the polynomial is that the vapor composition is related to the liquid composition by means of the vaporization equilibrium constant, K.

Derivation of Equations. Consider a feed of F mols to be either vaporized or condensed so that the fraction in the vapor, $\rho = V/F$ and in the liquid is $1 - \rho = L/F$. The mole fractions of the ith component in the feed, vapor, and liquid are respectively Z_i, Y_i, X_i.

From an over-all material balance:

$$F = V + L \text{ or } 1 = \rho + L/F \tag{1}$$

From an ith component material balance:

$$FZ_i = VY_i + LX_i \text{ or } Z_i = \rho Y_i + (1-\rho)X_i \tag{2}$$

The vapor is assumed to be in equilibrium with the liquid. Furthermore, the vapor composition is assumed to be related to the liquid composition by means of the vaporization equilibrium constant

$$Y_i = K_i X_i \tag{3}$$

Combining Equations (2) and (3), the composition of the ith component in the liquid is given by

$$X_i = \frac{Z_i}{\rho A_i + 1} \tag{4}$$

where $A_i = K_i - 1$

The sum of the mol fractions in the liquid is 1. Consequently:

$$\sum_{i=1}^{n} X_i = \sum_{i=1}^{n} \frac{Z_i}{\rho A_i + 1} = 1 \tag{5}$$

Applying Equation (5) to two, three and four component systems, the following equations are obtained:

$$A_1A_2(Z_1 + Z_2)\,\rho + A_1Z_1 + A_2Z_2 = 0 \quad \text{2 components} \tag{6a}$$

$$\text{or } \rho + \frac{Z_1}{A_2} + \frac{Z_2}{A_1} = 0 \tag{6a'}$$

$$A_1A_2A_3(Z_1 + Z_2 + Z_3)\,\rho^2 + [A_1A_2(Z_1 + Z_2) + A_2A_3(Z_2 + Z_3) + A_1A_3(Z_1 + Z_3)]\,\rho + A_1Z_1 + A_2Z_2 + A_3Z_3 = 0 \quad \text{3 component} \tag{6b}$$

$$\text{or } \rho^2 + \left[\frac{1-Z_1}{A_1} + \frac{1-Z_2}{A_2} + \frac{1-Z_3}{A_3}\right]\rho + \frac{A_1Z_1 + A_2Z_2 + A_3Z_3}{A_1A_2A_3} = 0 \tag{6b'}$$

$$A_1A_2A_3A_4(Z_1+Z_2+Z_3+Z_4)\,\rho^3$$
$$+[A_1A_2A_3(Z_1+Z_2+Z_3)+A_1A_2A_4(Z_1+Z_2+Z_4)+$$
$$A_2A_3A_4(Z_2+Z_3+Z_4)+A_1A_3A_4(Z_1+Z_3+Z_4)]\,\rho^2$$
$$+[A_1A_2(Z_1+Z_2)+A_1A_3(Z_1+Z_3)+A_1A_4(Z_1+Z_4)+$$
$$A_2A_3(Z_2+Z_3)+A_2A_4(Z_2+Z_4)+A_3A_4(Z_3+Z_4]\,\rho$$
$$+A_1Z_1+A_2Z_2+A_3Z_3+A_4Z_4=0 \qquad \text{4 component} \qquad (6c)$$

$$\text{or } \rho^3+\left[\frac{1-Z_1}{A_1}+\frac{1-Z_2}{A_2}+\frac{1-Z_3}{A_3}+\frac{1-Z_4}{A_4}\right]\rho^2+$$
$$\left[\frac{A_1A_2(Z_1+Z_2)+A_1A_3(Z_1+Z_3)+A_1A_4(Z_1+Z_4)}{A_1A_2A_3A_4}+\right.$$
$$\left.\frac{A_2A_3(Z_2+Z_3)+A_2A_4(Z_2+Z_4)+A_3A_4(Z_3+Z_4)}{A_1A_2A_3A_4}\right]\rho$$
$$+\frac{A_1Z_1+A_2Z_2+A_3Z_3+A_4Z_4}{A_1A_2A_3A_4}=0 \qquad (6c')$$

In general, there is a systematic method for writing the equation. The resulting equation is a n–1st degree polynomial in ρ:

$$\alpha_{n-1}\rho^{n-1}+\alpha_{n-2}\rho^{n-2}+\ldots\ldots+\alpha_1\rho+\alpha_o=0$$

Consider α_R, the coefficient of ρ^R. α_R consists of the sum of $\binom{n}{R+1}$ terms. These terms can be formulated by multiplying the product of the A_i's taken r + 1 at a time by the sum of the corresponding Z_i's taken r + 1 at a time.

For example in Equation (6b), the coefficient of ρ^2 consists of $\binom{3}{3}=1$ term. Note that n = 3 (ternary system) and r = 2. This term is $A_1A_2A_3(Z_1+Z_2+Z_3)=A_1A_2A_3$. It is formulated by multiplying the product of the A_i's taken (2 + 1) at a time by the sum of the corresponding Z_i's taken (2 + 1) at a time. The coefficient of ρ consists of $\binom{3}{1+1}=3$ terms. These terms are formulated by multiplying the product of the A_i's taken (1 + 1) at a time by the sum of the corresponding Z_i's taken (1 + 1) at a time. These terms are: $A_1A_2(Z_1+Z_2)+A_1A_3(Z_1+Z_3)+A_2A_3(Z_2+Z_3)$.

Application to Partial Vaporization or Condensation. If the temperature and pressure are specified, the vaporization equilibrium constants are known. Consequently, the A_i's are readily calculated. The fraction of the feed in the vapor, ρ is determined by finding the root of the n–1st degree polynomial that lies between 0 and 1. For a binary system, ρ is calculated directly from a first degree polynomial equation. The quadratic formula allows ρ to be computed readily for a ternary system. Even a four component system is not cumbersome because exact methods for solving cubic equations are available. For systems of more than four components, numerical methods are necessary for determining ρ but rapid convergence has been experienced.

If ρ and pressure are specified, then temperature is to be determined. A temperature is chosen, the K_i's and A_i's are determined, and the corresponding polynomial is calculated. This procedure is repeated until the polynomial is equal to zero. Apparently, for this type of application, the equations developed, offer no advantage over the usual method.[1]

Note that the polynomial equations reduce to the conventional bubble point and dew point equations if $\rho = 0$ and if $\rho = 1$ respectively.

Illustrative Example. Treybal[2] solves the following example by a conventional method.

A liquid containing 50 mole % benzene, 25 mole % toluene, 25 mole % o-xylene is flash vaporized at a temperature and pressure such that the K's are: 1.803, 0.724, 0.263. Compute the fraction vaporized. Solution:

$$A_1 = 1.803\text{-}1 = \ \ 0.803$$
$$A_2 = 0.724\text{-}1 = -0.276$$
$$A_3 = 0.263\text{-}1 = -0.737$$

n = 3 (three component system). Equation (6b′) is applicable.

$$\rho^2+\left[\frac{1-Z_1}{A_1}+\frac{1-Z_2}{A_2}+\frac{1-Z_3}{A_3}\right]\rho+\left[\frac{A_1Z_1+A_2Z_2+A_3Z_3}{A_1A_2A_3}\right]=0$$

$$\rho^2+\left[\frac{1-.5}{.803}+\frac{1-.25}{-.276}+\frac{1-.25}{-.737}\right]\rho+\left[\frac{(.803)(.5)+(2.76)(.25)-(.737)(.25)}{(0.803)(-0.276)(-0.737)}\right]=0$$

$$\rho^2-3.112\rho+0.908=0$$

$$\rho=0.326$$

NOMENCLATURE

$A_i = K_i - 1$
F = moles of feed
K_i = vaporization equilibrium constant for i^{th} component
L = moles of liquid
n = number of components in system
v = moles of vapor
X_i = mole fraction of i^{th} component in liquid
Y_i = mole fraction of i^{th} component in vapor
Z_i = mole fraction of i^{th} component in feed
ρ = fraction of feed in the vapor

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Key Words for Indexing

Condensation, Distillation, Equilibrium, Multi-Component, Vaporization

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What's Your Interest Rate?

Here's how to calculate, use and interpret the interest rate (profitability index, discounted cash flow rate of return) for the profit-making return you're considering

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New York City

Interest rate, an investment schedule and a repayment schedule characterize a financial venture. Loans, where the interest rate is stipulated and from it the repayment schedule calculated, are the simplest mathematically. However, for financial ventures other than loans, the repayment schedule is stipulated and from it the interest rate is calculated. The mathematics of doing this are difficult. Hence the use of interest rate to characterize financial ventures other than loans is a phenomenon of the last quarter-century, paralleling the increased use of mathematics in business.

Among special terms used for the interest rate for financial ventures other than loans are the following:

Discounted Cash Flow (DCF) Rate of Return
Profitability Index (PI)
Interest Rate of Return
Rate of Return by the Investor's Method
Time Value of Money

Whatever name is assigned to this concept, it is defined as the compound interest rate which a bank would have to pay in order to accept and return cash on the same schedule as the venture being considered.

Comparison with Other Criteria. Often a proposed venture is characterized by its return on investment when operating at full design capacity. Although return on investment and interest rate are both expressed as percent per year, they are fundamentally different concepts because the definition of return on investment at capacity allows for neither the time required to reach capacity nor the life of the investment.

Cash recovery time is in principle a more rigorous economic criterion than return on investment at capacity because the calculation of cash recovery time demands a year-by-year analysis of cash flow. Those now calculating cash recovery time will find it simple to calculate interest rate as well, since little more effort is required.

Taken together, return on investment at capacity and cash recovery time provide a satisfactory economic characterization of a proposed venture. One advantage of interest rate is that it provides this characterization in one number instead of two.

Why Calculate Interest Rate? The ultimate reason for calculating the interest rate for a proposed venture is to assist management to decide whether to carry out the venture. Thus any given proposal can be rated against the cost of the cash required to implement it. Thus alternative proposals to accomplish the same objective can be compared with one another.

What Is a Desirable Interest Rate? Interest rate is bounded above by ethics and below by the cost of cash. No one can say absolutely where it should lie in between,

TABLE 1—Basic Data

Initial Time: January 1, 1963
Initial Value of the Investment: Zero
Final Time: December 31, 1983
Final Value of the Investment: $3.00 MM (working capital)
Schedule of Annual Cash Flows:

Year	Net Cash Flow During the Year, $MM
1963	(15.30)
1964	(0.25)
1965	1.12
1966	1.99
1967	2.65
1968	3.05
1969	3.38
1970	3.48
1971	3.48
1972	3.48
1973	3.48
1974	2.96
1975	2.96
1976	2.96
1977	2.96
1978	2.96
1979	2.96
1980	2.96
1981	2.96
1982	2.96
1983	2.96

TABLE 2—Calculation of Net Cash Flow In Each Year

Parentheses are used to denote cash flowing from the investor to the investment.

Year	Fixed Capital, $MM	Working Capital, $MM	Net Profit, $MM	Depreciation, $MM	Net Cash Flow, $MM
1963	(15.00)	(0.30)	...	...	(15.30)
1964	0	(0.70)	(0.80)	1.25	(0.25)
1965	0	(0.80)	0.67	1.25	1.12
1966	0	(0.60)	1.34	1.25	1.99
1967	0	(0.30)	1.70	1.25	2.65
1968	0	(0.20)	2.00	1.25	3.05
1969	0	(0.10)	2.23	1.25	3.38
1970	0	0	2.23	1.25	3.48
1971	0	0	2.23	1.25	3.48
1972	0	0	2.23	1.25	3.48
1973	0	0	2.23	1.25	3.48
1974	0	0	2.71	0.25	2.96
1975	0	0	2.71	0.25	2.96
1976	0	0	2.71	0.25	2.96
1977	0	0	2.71	0.25	2.96
1978	0	0	2.71	0.25	2.96
1979	0	0	2.71	0.25	2.96
1980	0	0	2.71	0.25	2.96
1981	0	0	2.71	0.25	2.96
1982	0	0	2.71	0.25	2.96
1983	0	0	2.71	0.25	2.96

This cash flow schedule describes a case in which a plant is built in 1963. During that year a total of $15 MM fixed capital is expended, with $10 MM being process capital and $5 MM auxiliary capital. In addition, working capital of $0.30 MM is invested in 1963 in order to allow operations to begin.

Operation commences in 1964. The plant shows a loss in the first year, but the net profit increases steadily as sales increase. During 1970 and thenceforth the plant operates at capacity. The net cash flow declines from 1973 to 1974 because depreciation on the $10 MM process capital is no longer allowable as an income tax deduction after the end of 1973. The remaining depreciation is on auxiliary capital.

although the risk involved in the venture is a major determining factor. To set the desired interest rate is the duty, as well as the prerogative, of management.

HOW TO CALCULATE INTEREST RATE

First, define the system; second, tabulate five items of basic data; third, perform the mechanics of the calculation.

To define the system is to state who is the investor and what is the investment and then identify all cash flows between them during the time period under consideration. For example, if management is the investor and a proposed plant is the investment, cash inflows from the investor to the investment include fixed and working capital; cash outflows include net profit and depreciation.

The five items of basic data are:

1. The date of initial investment
2. The value of the investment on the initial date
3. The cash flow schedule
4. The date considered as the end of the evaluation period
5. The value of the investment on the final date.

For example, the following would be specified for a bond:

1. The date of purchase
2. The purchase price
3. The nominal interest rate, and the schedule of interest payments
4. The date of redemption
5. The redemption price.

The initial date is usually chosen as the time when expenditures for the construction of commercial facilities begin. The final date is usually chosen as the time when either the equipment, the process or the product is expected to become obsolete.

The final value of the investment is the liquidation value on the final date. Virtually all the working capital should be recoverable. Of the fixed capital, often only the salvage value is recoverable, with a gross exception being the sale of a relatively new plant or business to another corporation.

The cash flow schedule is the same as that used to determine cash recovery time.

There are two ways to perform the mechanics of the calculation of interest rate:

A. Pick a trial value of interest rate r. Plot e^{-rt} against cumulative cash flow C. Determine the area under the curve. Repeat until a value of r is found such that the area becomes equal to $I_0e^{-rt_0} - I_2e^{-rt_F}$.

B. Pick a trial value of r. Multiply the net cash flow in each year by a discounting factor which has previously been computed and tabulated as a function of t and r. Determine the algebraic sum of the products so obtained. Repeat until this sum becomes equal to $I_0e^{-rt_0} - I_2{}^{-rt_F}$.

Example. Suppose management is considering the investment of $15 MM fixed capital, and $3 MM working capital, in a new plant. The five items of basic data are shown in Table 1. (The cash flow schedule for Table 1 is computed as shown in Table 2, in which the net cash flow for any given year is calculated as the algebraic sum

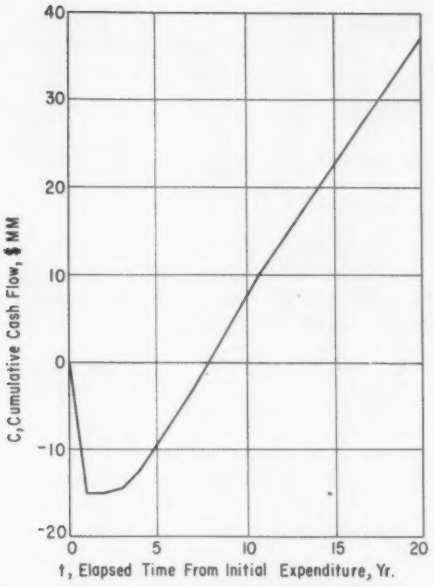


FIGURE 1—Funds flow into the project until sales and production increase for a positive cash flow.

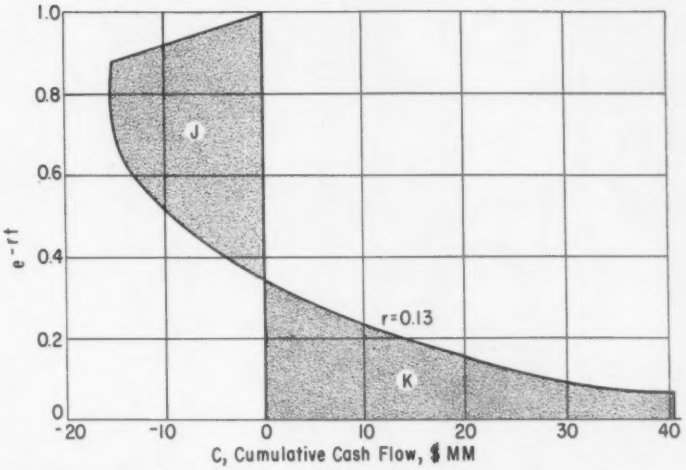


FIGURE 2—This plot of e^{-rt} versus cumulative cash flow for various values of r can be used for determining the interest rate r.

of net profit, depreciation, fixed capital and working capital flowing in that year.)

Method A

1. Tabulate the cumulative cash flow C versus the time t in years from the start of the evaluation period.

Cumulative cash flow is defined as the algebraic sum of the net cash flows over the time period between t_o and t. For example, as shown in Table 3, C at t = 3 is

$$-15.30 - 0.25 + 1.12 = -14.43$$

A plot of C versus t yields the cash flow curve shown in Figure 1.

2. Pick a trial value of r and compute $I_o e^{-rt_o} - I_2 e^{-rt_F}$. Here I_o = zero, I_2 = \$3.00 MM working capital, and $t_F = 21$ years. Thus $I_o e^{-rt_o} - I_2 e^{-rt_F} = -0.18$ for r=0.13.

TABLE 3—Cumulative Cash Flow Tabulation

Year	Elapsed Time At End of Year, yr	Cumulative Cash Flow, $MM
1963	1	(15.30)
1964	2	(15.55)
1965	3	(14.43)
1966	4	(12.44)
1967	5	(9.79)
1968	6	(6.74)
1969	7	(3.36)
1970	8	0.12
1971	9	3.60
1972	10	7.08
1973	11	10.56
1974	12	13.52
1975	13	16.48
1976	14	19.44
1977	15	22.40
1978	16	25.36
1979	17	28.32
1980	18	31.28
1981	19	34.24
1982	20	37.20
1983	21	40.16

3. Plot e^{-rt} against C. It is unnecessary to compute e^{-rt} for every value of C in Table 3. Only enough values to define the shape of the curve of Figure 2 need be selected. For example, at r = 0.13, the following tabulation is sufficient to allow a good plot of Figure 2:

C, $MM	t, yr	$e^{-0.13t}$
0	0	1.00
(15.3)	1	0.88
(15.6)	2	0.77
(14.4)	3	0.68
(12.4)	4	0.49
(3.4)	7	0.40
7.1	10	0.27
25.4	16	0.12
40.2	21	0.06

4. Determine the values of areas J and K, shown in Figure 2. J is negative and K is positive.

5. Repeat for other values of r until one is found such that area J exceeds area K by 0.18. In this case the correct value of r is 0.13.

Method B

1. Secure a previously prepared work sheet on which are tabulated discounting factors g. The format in which these factors are presented is usually similar to that of Table 4.

2. Enter the net cash flow schedule from Table 1 on the left-hand side of the work sheet.

3. Pick a trial value of r and calculate $I_o e^{-rt_o}$. No value is shown in Table 4 because I_o equals zero.

4. In the column corresponding to the trial value of r, multiply the net cash flow for each year by the corre-

TABLE 4—Tabular Solution (Method B)

Basis: Each annual cash flow is multiplied by a factor g, defined by $g = e^{-rt}(e^r - 1)/r$

Year	Elapsed Time at End of Yr, yr	Net Cash Flow During The Yr, $MM	g at r = 0.1	$MM	g at r = 0.15	$MM	g at r = 0.2	$MM
1963	1	(15.30)	0.952	(14.60)	0.930	(14.22)	0.906	(13.87)
1964	2	(0.25)	0.861	(0.22)	0.800	(0.29)	0.742	(0.19)
Total for Negatives				(14.82)		(14.42)		(14.06)
1965	3	1.12	0.779	0.87	0.688	0.77	0.608	0.68
1966	4	1.99	0.705	1.40	0.592	1.18	0.498	0.99
1967	5	2.65	0.638	1.69	0.509	1.34	0.407	1.08
1968	6	3.05	0.577	1.76	0.438	1.34	0.334	1.02
1969	7	3.38	0.522	1.76	0.378	1.28	0.273	0.92
1970	8	3.48	0.473	1.65	0.324	1.13	0.224	0.78
1971	9	3.48	0.427	1.49	0.280	0.97	0.183	0.64
1972	10	3.48	0.387	1.34	0.241	0.84	0.150	0.52
1973	11	3.48	0.350	1.22	0.207	0.72	0.122	0.42
1974	12	2.96	0.317	0.94	0.178	0.53	0.100	0.30
1975	13	2.96	0.277	0.82	0.154	0.46	0.082	0.24
1976	14	2.96	0.259	0.77	0.132	0.39	0.062	0.18
1977	15	2.96	0.235	0.70	0.114	0.34	0.055	0.16
1978	16	2.96	0.212	0.63	0.098	0.29	0.045	0.13
1979	17	2.96	0.192	0.57	0.084	0.25	0.037	0.11
1980	18	2.96	0.173	0.51	0.073	0.21	0.030	0.09
1981	19	2.96	0.157	0.46	0.063	0.19	0.024	0.07
1982	20	2.96	0.143	0.42	0.053	0.16	0.020	0.06
1983	21	2.96	0.128	0.38	0.047	0.14	0.016	0.05
			e^{-rt_F}		e^{-rt_F}		e^{-rt_F}	
	21	3.00	0.122	0.36	0.043	0.13	0.015	0.04
Total for Positives				19.74		12.76		8.48
Algebraic Total				4.92		(1.66)		(5.58)

TABLE 5—Approximate Solution

Basis: Each annual cash flow multiplied by a factor $h = 1/(1+r)^t$

Year	Elapsed Time at End of Yr, yr	Net Cash Flow During The Yr, $MM	h at r = 0.14	$MM	h at r = 0.15	$MM
1963	1	(15.30)	0.878	(13.43)	0.870	(13.30)
1964	2	(0.25)	0.770	(0.19)	0.756	(0.19)
Total for Negative Flows				(13.62)		(13.49)
1965	3	1.12	0.675	0.76	0.658	0.74
1966	4	1.99	0.592	1.18	0.572	1.14
1967	5	2.65	0.520	1.38	0.497	1.32
1968	6	3.05	0.456	1.39	0.432	1.32
1969	7	3.38	0.400	1.35	0.375	1.26
1970	8	3.48	0.350	1.22	0.326	1.13
1971	9	3.48	0.308	1.07	0.283	0.98
1972	10	3.48	0.270	0.94	0.237	0.82
1973	11	3.48	0.237	0.82	0.206	0.72
1974	12	2.96	0.208	0.61	0.179	0.53
1975	13	2.95	0.182	0.54	0.159	0.47
1976	14	2.96	0.160	0.47	0.138	0.41
1977	15	2.96	0.140	0.41	0.120	0.36
1978	16	2.96	0.123	0.36	0.104	0.31
1979	17	2.96	0.108	0.32	0.090	0.27
1980	18	2.96	0.095	0.28	0.079	0.23
1981	19	2.96	0.083	0.25	0.068	0.20
1982	20	2.96	0.073	0.22	0.059	0.18
1983	21	2.96	0.064	0.19	0.052	0.15
	21	3.00	0.064	0.19	0.052	0.15
Total for Positive Flows				13.95		12.69
Algebraic Total				0.33		(0.80)

sponding g factor for that year. For example, at r = 0.1 the cash flow for the third year is multiplied by 0.779.

5. Calculate $I_2e^{-rt_F}$ as shown.

6. Calculate the algebraic sum of all the foregoing products of cash flows and g factors.

7. Repeat for other values of r until this sum becomes zero. The computations of Table 4 indicate that the sum is greater than zero for r = 0.10 and less than zero for r = 0.20. The correct value of r, 0.13, can conveniently be determined by plotting the sum against r and determining the zero intercept.

Horseback Estimates

1. Pick a trial value of r and multiply the cash flow in each year, as given in Table 1, by

$$1/(1+r)^t$$

Repeat until the algebraic sum of the products is equal to

$$I_o/(1+r)^{t_o} - I_2/(1+r)^{t_F}$$

This procedure is illustrated in Table 5. The interest rate appears to lie between 0.14 and 0.15. This is a high value but is pretty good considering that neither handbooks nor prepared forms are needed to calculate it.

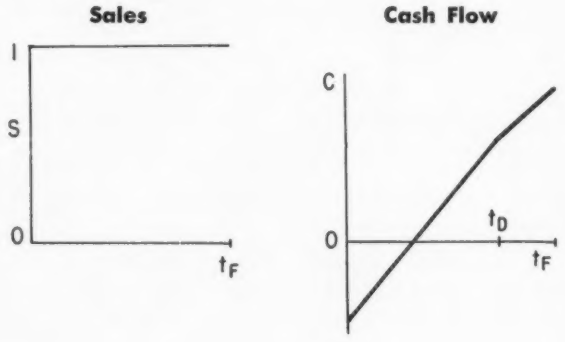
2. Calculate the net return on investment at capacity.

$$N = 2.23/18.00 = 0.12$$

N is in this case a close approximation to the interest rate. The trouble is that N is not dependable as an approximation in all cases. If a venture realizes its capacity earning power rapidly, r will be greater than N. If a venture realizes its capacity earning power slowly, N will be greater than r.

Effect of Sales Rate

1. If the venture attains capacity immediately after being placed in operation, and if the capital inflow occurs over a very brief time period before the start of operation, the curve of sales versus time, and the corresponding cash flow curve, will appear as follows:

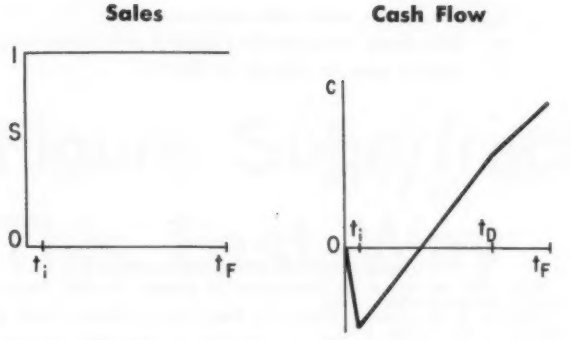


A specific example of the foregoing would be the addition of a new heat exchanger to debottleneck an existing production unit. Here $N = (m-n)/(I_F + I_W)$, but r is given by

$$-I_We^{-rt_F} = -(I_F + I_W) + (m-n+d)\frac{1-e^{-rt_D}}{r} + (m-n'+d')\frac{e^{-rt_D}-e^{-rt_F}}{r}$$

For t_F large and $(m-n+d)$ approximately equal to $(m-n'+d')$, $r = (m-n+d)/I_F + I_W$, which exceeds N by $d/(I_F + I_W)$.

2. If the venture attains capacity immediately but a significant time is required for the initial capital expenditure, the sales and cash flow curves appear as follows:

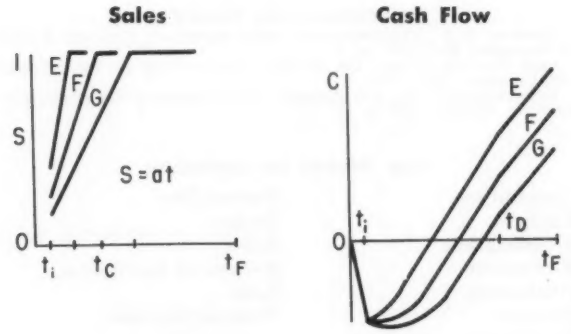


N is the same as in Case 1, but the equation for r is different:

$$-I_W e^{-rt_F} = -(I_F + I_W)\frac{e^{-rt_i} - e^{-rt_c}}{r} + (m - n + d)$$

$$\frac{e^{rt_c} - e^{-rt_D}}{r} + (m - n' + d')\frac{e^{rt_D} - e^{-rt_F}}{r}$$

3. If the sales rate attains capacity over a period of years and is directly proportional to time during that period, and if a significant time is required for the initial capital expenditure, the sales and cash flow curves appear as follows:



Again the equation for N is the same as in Cases 1 and 2, but the equation for r is different, as follows:

$$-I_W e^{-rt_F} = -(I_F + I'_W)\frac{1 - e^{rt_i}}{r}$$

$$+ \frac{ma}{r}\left[e^{-rt_i}\left(t_i + \frac{1}{r}\right) - e^{-rt_c}\left(t_c + \frac{1}{r}\right)\right]$$

$$+ [d - n - a(I_W - I'_W)]\frac{e^{-rt_i} - e^{-rt_c}}{r}$$

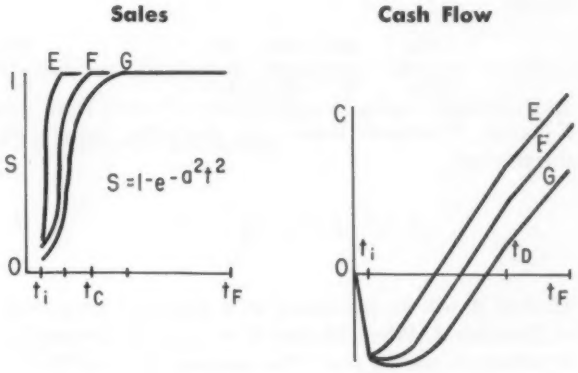
$$+ (m - n + d)\frac{e^{-rt_c} - e^{-rt_D}}{r} + (m - n' + d')\frac{e^{-rt_D} - e^{-rt_F}}{r}$$

The faster the sales approach capacity, the higher the interest rate. Thus the interest rate for Curve E is higher than that for Curve G.

4. If the sales rate attains capacity over a period of years, being related to time by an "S-curve" of the form

$$S = 1 - e^{-a^2t^2}$$

and if a significant length of time is required for the initial capital expenditure, the sales and cash flow curves appear as follows:



Once again the equation for N is the same as in all the foregoing cases, but the equation for r is different, as follows:

$$-I_W e^{-rt_F} = -(I_F + I'_W)\frac{1 - e^{-rt_i}}{r}$$

$$+ (m - n + d)\frac{e^{-rt_i} - e^{-rt_D}}{r}$$

$$- [m - r(I_W - I'_W)]\frac{e^{\frac{r^2}{4a^2}}\sqrt{\pi}}{a}[Q(x_{t_c}) - Q(x_{t_i})]$$

$$- (I_W - I'_W)\left[e^{-(rt_i + a^2t_i^2)} - e^{-(rt_c + a^2t_c^2)}\right]$$

$$+ (m - n' + d')\frac{e^{-rt_D} - e^{-rt_F}}{r}$$

Here as in Case 3 the interest rate is higher as the sales rate approaches capacity faster, and thus the interest rate is higher for Curve E than for Curve G.

Effect of Depreciation. All depreciation methods eventually return the same amount of cash, but some return it sooner. Thus, all other things equal, the interest rate will be higher for that depreciation rate which returns the fixed capital the quickest.

Mathematical Basis. Methods A and B, as well as the equations of Cases 1 through 4, are based on an integration of a differential cash balance on the investment. This balance can be depicted as follows:

Cash Balance

A differential cash balance during time dt yields

$$dD + dA = dE + dB + dI \quad (1)$$

Define

$$r \text{ by } \quad rIdt = dA - dB \quad (2)$$

$$C \text{ by } \quad dC = dE - dD \quad (3)$$

Equation 1 becomes linear and first-order, integrating therefore to

$$I_o e^{-rt_o} - I_2 e^{-rt_F} = \int_{t_o}^{t_F} e^{-rt} dC \quad (4)$$

Method A will be recognized as a graphical integration of Equation 4. When Method B is used, the integration is performed year by year. The equations for r in Cases 1 through 4 were developed by expressing C as a function of t and integrating analytically.

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NOMENCLATURE

a	a constant
C	cumulative cash flow, $ MM
d	straight-line depreciation, $ MM/yr, before t_D
d′	straight-line depreciation, $ MM/yr, after t_D
e	base of natural logarithms = 2.7183
F	fixed costs excluding depreciation, $ MM/yr
g	discounting factor
h	approximate discounting factor
I_o	value of the investment, $ MM, at time t_o
I_2	value of the investment, $ MM, at time t_F
I_F	total fixed capital, $ MM
I_W	total working capital, $ MM
I'_W	working capital, $ MM, at time t_i
m	p (P — V), $ MM/yr
n	p (F + d), $ MM/yr
n′	p (F + d′), $ MM/yr
N	net return on investment at capacity, %/yr
p	income tax as a fraction
P	sales rate at capacity, $ MM/yr
r	interest rate, percent per yr
s	ratio of actual to capacity sales
t	time, years
t_o	time when the evaluation period begins
t_F	time, years, at the end of the evaluation period
t_c	time, years, when capacity sales are realized
t_i	time, years, when sales commence
t_D	time, years, when process capital is fully depreciated
V	variable costs at capacity, $ MM/yr
x	$a\sqrt{2}\left(t + \frac{r}{2a^2}\right)$
Q(x)	$\frac{1}{\sqrt{2\pi}} \int_{\infty}^{x} e^{-\frac{x^2}{2}} dx$

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Key Words for Indexing

Accounting
Costs
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Economics
Evaluation
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Profits
Rates
Return on Investment
Sales
Working Capital

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Oliver Axtell is a chemical engineer in the Planning Department of Celanese Chemical Company, New York City. Mr. Axtell is primarily engaged in economic evaluation of chemical projects. Prior to joining Celanese, Mr. Axtell was an instructor in chemical engineering at the University of Maine. With Celanese he has spent five years in research and development and the remainder in economic evaluation. Mr. Axtell received a B.S. in chemical engineering from Rice University and a S.M. in chemical engineering from Massachusetts Institute of Technology.

Figure Superfractionation This Fast Way

These equations are streamlined for speed in making binary superfractionation calculations. They will handle varying relative volatilities and will give speed without sacrifice of accuracy

Alvin E. Harkins and Roland A. Taub
Monsanto Chemical Company, Texas City, Texas

This new method uses the following explicit equations for the theoretical plate requirements at any chosen reflux at least 5 percent above minimum:

For the rectifying section:

$$S = \frac{\ln\left[\frac{1-x_o}{x_j-x_d}\right]}{\ln \alpha_d\, L/V} + \frac{\ln\left[\frac{1-x_g}{x_o-x_g}\right]}{\ln \alpha_o\, L/V} \qquad (1)$$

Where:

$$x_g = \frac{1-L/V}{(L/V)(\alpha_o-1)} - \frac{(1-L/V)(1-x_d)}{(L/V)(\alpha_o L/V-1)}$$

$$x_j - x_d = \frac{(\alpha_d-1)(1-x_d)}{(\alpha_d L/V-1)}$$

For the stripping section:

$$S = \frac{\ln\left[\frac{x_o}{x_w-x_a}\right]}{\ln \frac{\alpha_w}{L'/V'}} + \frac{\ln\left[\frac{x_b}{x_b-x_o}\right]}{\ln \frac{\alpha_o}{L'/V'}} \qquad (2)$$

Where:

$$x_b = \frac{\alpha_o - L'/V'}{(L'/V')(\alpha_o-1)} + \frac{\alpha_o(L'/V'-1)x_w}{(L'/V')(\alpha_o-L'/V')}$$

$$x_w - x_a = \frac{x_w(\alpha_w-1)}{(\alpha_w-L'/V')}$$

These equations will handle varying relative volatilities and will offer speed without sacrificing accuracy.

THE EQUATIONS DERIVED

Winn[4] proposed the following relationship for calculating the number of trays in the stripping section:

$$S = \frac{\ln\left[\frac{x_o-x_a}{x_w-x_a}\right]}{\ln \beta''} + \frac{\Theta'' \ln\left[\frac{x_b-x_w}{x_b-x_o}\right]}{\ln \beta''} \qquad (3)$$

Where:

$$\beta'' = \frac{\left(\frac{dy^*}{dx}\right)_a}{L'/V'} \text{ and } \Theta'' = \frac{\ln \beta''}{\ln\left[\left(\frac{L'}{V'}\right)\Big/\left(\frac{dy^*}{dx}\right)_b\right]}$$

Winn employs trial-and-error solutions to compute values for x_a, x_b, β'' and Θ''. Typical superfractionator purities are in the 98+% range. This range of purity allows simplifications which eliminate the need for involved trial-and-error computation. Equation (3) will

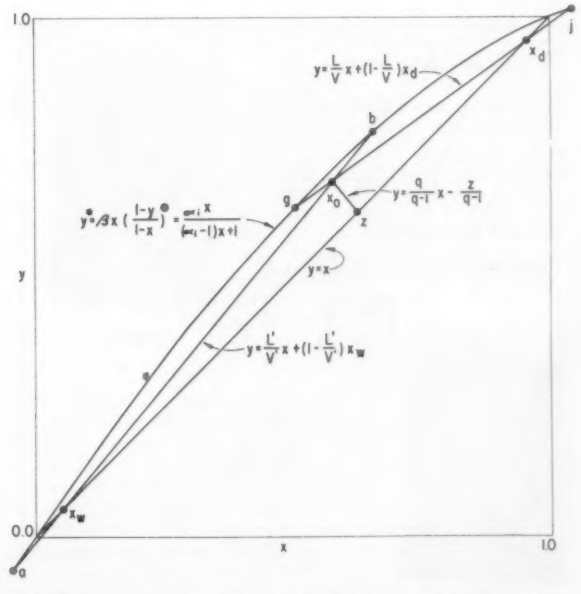

FIGURE 1—An extended McCabeThiele diagram shows intersections of the operating lines with equilibrium curve.

now be reduced to a simple, explicit form, starting with the term,

$$\frac{\ln\left[\frac{x_o - x_a}{x_w - x_a}\right]}{\ln \beta''}:$$

Since $x_w \cong 0$, $x_a \cong 0$ and:

$$(x_o - x_a) \cong x_o \tag{4}$$

The equilibrium curve between x_a and x_w may be represented by $y^* = \alpha_w x$. Therefore,

$$\beta'' = \frac{\alpha_w}{L'/V'} \tag{5}$$

Also,

$$\alpha_w x_a = L'/V' x_a + (1 - L'/V') x_w$$

$$x_a = \frac{(1 - L'/V') x_w}{\alpha_w - L'/V'}$$

Solving for $(x_w - x_a)$:

$$x_w - x_a = \frac{x_w (\alpha_w - 1)}{\alpha_w - L'/V'} \tag{6}$$

Therefore, the first term in Equation (3) becomes

$$\frac{\ln\left[\frac{x_o - x_a}{x_w - x_a}\right]}{\ln \beta''} = \frac{\ln\left[\frac{x_o}{x_w - x_a}\right]}{\ln \frac{\alpha_w}{L'/V'}} \tag{7}$$

Taking the remaining term,

$$\frac{\Theta'' \ln\left[\frac{x_b - x_w}{x_b - x_o}\right]}{\ln \beta''}, \text{ and simplifying:}$$

$$x_b - x_w \cong x_b \tag{8}$$

At x_b,

$$\frac{\alpha_b x_b}{(\alpha_b - 1) x_b + 1} = (L'/V') x_b + (1 - L'/V') x_w \cong (L'/V') x_b$$

$$x_b = \frac{\alpha_b - L'/V'}{(L'/V')(\alpha_b - 1)} \tag{9}$$

$$\left(\frac{dy^*}{dx}\right)_b = \frac{\alpha_b}{[(\alpha_b - 1) x_b + 1]^2} = \frac{[L'/V']^2}{\alpha_b}$$

As $x_b \to x_o$, $\alpha_b \to \alpha_o$

Therefore, in the region of $x_b \cong x_o$

$$\left(\frac{dy^*}{dx}\right)_b = \frac{[L'/V']^2}{\alpha_o}$$

From whence:

$$\Theta'' = \frac{\ln \beta''}{\ln \frac{\alpha_o}{L'/V'}} \tag{10}$$

Also,

$$x_b = \frac{\alpha_o - L'/V'}{(L'/V')(\alpha_o - 1)} \tag{11}$$

From the foregoing relationships, it may now be shown that:

$$\frac{\Theta'' \ln\left[\frac{x_b - x_w}{x_b - x_o}\right]}{\ln \beta''} = \frac{\ln\left[\frac{x_b}{x_b - x_o}\right]}{\ln \frac{\alpha_o}{L'/V'}} \tag{12}$$

Substitution of Equations (7) and (12) into Equation (3) will yield Equation (2). Similarly, Equation (1) can be developed from Winn's method when $x_d \cong 1.0$ and $\alpha_g \cong \alpha_o$.

Values of x_b calculated from Equation (11) will be slightly below the true values at any product purity other than $x_w = 0$. This may cause an excessive number of plates to be calculated as the reflux approaches the minimum value, since the value calculated for $(x_b - x_o)$ may be several-fold smaller than the true value. However, a suitable correction factor may be developed by assuming that the equilibrium curve is a straight line over the range of correction. The relationships for x_g and x_b defined in Equations (1) and (2) include the proper correction factors.

The value of x_o to be used in Equations (1) and (2) may be readily calculated from either of the following relationships:

$$x_o = \frac{z - (1 - q)(1 - L/V) x_d}{1 - (1 - q)(1 - L/V)} \tag{13}$$

$$x_o = \frac{z + (1 - q)(L'/V' - 1) x_w}{1 + (1 - q)(L'/V' - 1)} \tag{14}$$

The term, q, is the thermal condition of the feed. When molal overflow is constant, q is the fraction of the feed not vaporized or the equivalent.

WHEN THE EQUATIONS APPLY

Just how impure x_d and x_w can be without causing significant error is dependent upon the relative volatility and reflux ratio. Generally, however, as long as $x_d \geqq 0.98$ and $x_w \leqq 0.02$, this method will give accurate results. Using the corrected equations for x_g and x_b will allow computations to be performed at these purity levels with reflux ratios equal to or greater than 1.05 times the minimum.

Generally, the values of α_b and α_g will be close enough to α_o to eliminate errors. If the values of α_b and α_g do deviate from α_o the values of $(x_b - x_o)$ and $(x_o - x_g)$ must necessarily be large. Therefore, terms involving α_o in Equations (1) and (2) will contribute few trays to the total, thus minimizing any errors.

The method in its present form obviously requires a constant molal overflow. However, it is suggested that if L/V is computed at the product and feed points for a particular section, a small variation in L/V may be handled by computing x_g or x_b at feed tray L/V and computing $(x_j - x_d)$ or $(x_w - x_a)$ at terminal conditions; $\frac{\alpha_o}{L'/V'}$ or α_o L/V would be computed at feed tray conditions and $\frac{\alpha_w}{L'/V'}$ or α_d L/V at terminal conditions. The assumption that the method will handle small changes in L/V has not been verified by calculation, but mathematically it appears that answers yielded would be reasonable approximations.

The equilibrium data should obey the relation, K =

$\beta\,(k)^{\theta}$, since this is a restriction on Winn's method. This equilibrium relationship will be valid for most systems and imposes very little limitation.

The equations developed are good for any binary system as long as the preceding conditions are met. If the relative volatility is constant ($\alpha_d = \alpha_o = \alpha_w$), the equations presented are reduced to a form which may also be derived from the method of Stoppel.[3]

Equations (1) and (2) may be solved rapidly using only a slide rule. Solution time is only a matter of minutes after equilibrium data and column balances have been established.

SOME EXAMPLES

Example No. 1—Winn's example problem:

$z = 0.60$	$\alpha_d = 1.431$
$x_d = 0.98$	$\alpha_o = 1.301$
$x_w = 0.002$	$\alpha_w = 1.200$
$q = 0.60$	$L/V = 0.885$
	$L'/V' = 1.079$

Rectifying Section:

$x_o = 0.582$

$x_j - x_d = 0.0324$

$x_g = 0.4145$

$S = 19.7$ theo. trays; by Winn's method $= 18.7$

Stripping Section:

$x_b = 0.683$

$x_w - x_a = 0.00331$

$S = 58.5$ theo. trays; by Winn's method $= 58.7$

Example No. 2—Smoker[2] has calculated the following problem by a rigorous method:

$z = x_o = 0.40$	$L/V = 0.75$
$x_d = 0.99$	$L'/V' = 1.378$
$x_w = 0.01$	$\alpha = 2.50$

Rectifying Section:

$x_g = 0.219$

$x_j - x_d = 0.01714$

$S = 8.0$ theo. trays; by Smoker's method $= 7.9$

Stripping Section:

$x_b = 0.549$

$x_w - x_a = 0.01337$

$S = 7.9$ theo. trays; by Smoker's method $= 7.8$

The accuracy demonstrated on these two example problems is comparable to (or better than) the accuracy one would normally expect from a McCabe-Thiele[1] graphical solution.

ACKNOWLEDGMENT

The authors wish to thank Dr. K. Sewall McMahon for his helpful comments and encouragement.

Symbols Used

α — relative volatility
β — constant in equation $K = \beta\,(k)^{\theta}$
β'' — variable defined in Equation (3)
θ — constant in Equation $K = \beta\,(k)^{\theta}$
θ'' — variable defined in Equation (3)
K — vapor-liquid distribution coefficient of light component
k — vapor-liquid distribution coefficient of heavy component
L — liquid rate, moles/unit time
q — thermal condition of feed
S — number of theoretical plates in a section
V — vapor rate, moles/unit time
x — mole fraction light component in liquid
y — mole fraction light component in vapor
y^* — equilibrium value of y
z — mole fraction light component in feed

SUBSCRIPTS

a, b — lower and upper intersection of stripper operating line with equilibrium curve, respectively
g, j — lower and upper intersection of rectifier operating line with equilibrium curve, respectively
i — individual point on equilibrium curve
d — distillate product
o — feed plate
w — bottoms product

SUPERSCRIPTS

′ — (prime) stripping section

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Key Words for Indexing

Binary Distillation Computations

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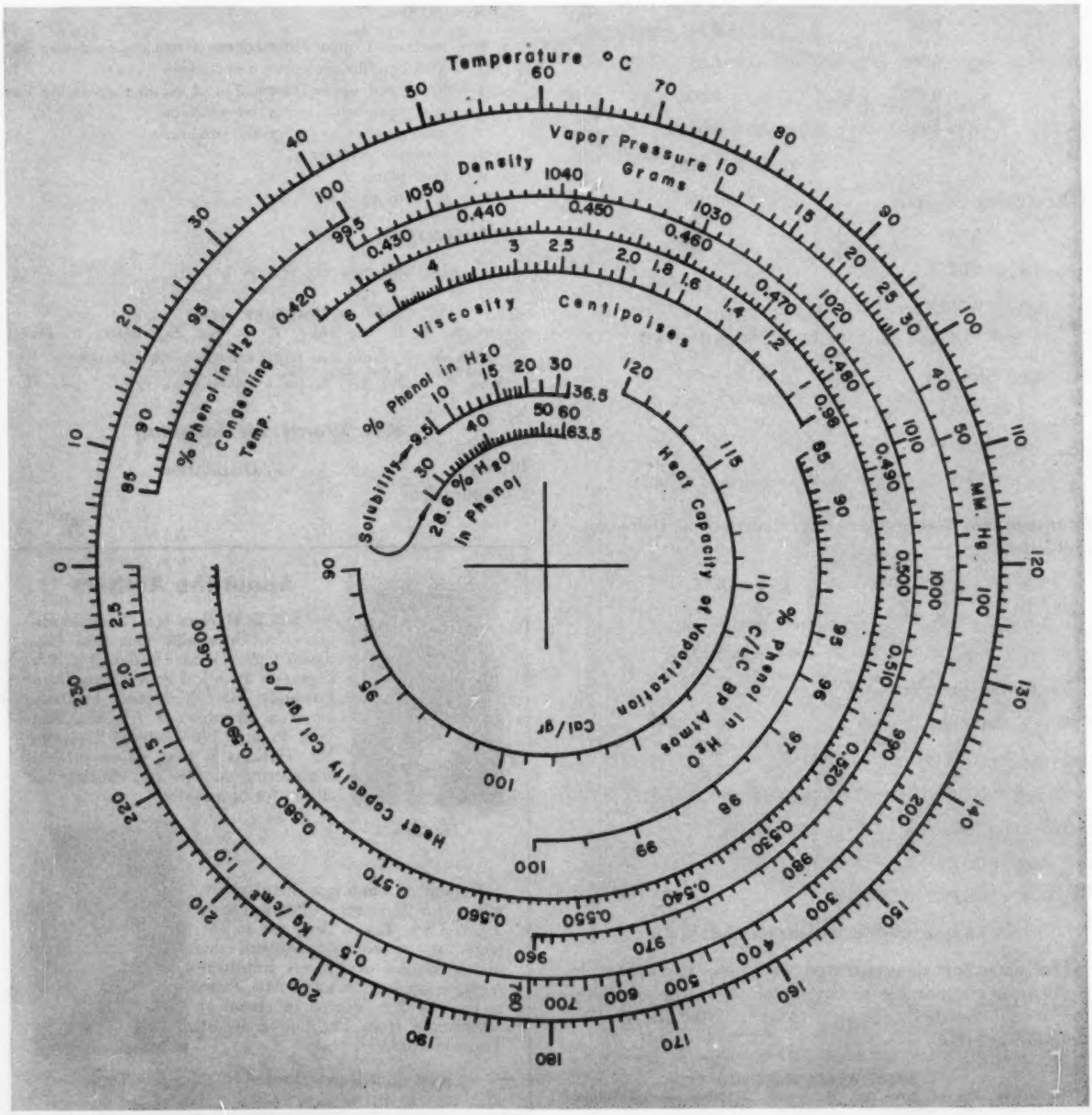
Find Phenol Properties By Nomograph

Remy Van Haelst, Antwerp, Belgium

This nomograph gives the most important properties of liquid phenol. It has been constructed from literature values; however, the data on heat properties are empirical. The use of the nomograph is as follows: any line passing through the center intersects the scales in corresponding property points.



Solubility of Hexane in Water

Arvind P. Kudchadker and John J. McKetta
The University of Texas, Austin

The solubility of n-hexane in water was determined at temperatures of 100, 160, 220 and 280°F and at pressures from 25 to 525 psia. No data have been published on solubility of hexane in water although Scheffer[2] did an extensive study of the hexane-water system and reported the solubility of water in hexane.

Apparatus and Materials. The apparatus for producing equilibrium conditions is essentially the same as described earlier.[1] The analytical procedure is also the same.

The *n*-hexane was supplied by the Phillips Petroleum Company with a certified purity of at least 99.0 mole percent. No further attempt was made to purify this material. The water was taken from the laboratory distilled water supply and was boiled to remove any dissolved gasses.

Results. The experimental data are shown in Table 1. These are plotted in Figure 1 as a pressure-composition

TABLE 1—Experimental Data—Solubility of *n*-Hexane in Water

Pressure psia	Mole Fr. Hexane x 10^4	Pressure psia	Mole Fr. Hexane x 10^4	Pressure psia	Mole Fr. Hexane x 10^4	Pressure psia	Mole Fr. Hexane x 10^4
100 °F		160 °F		220 °F		280 °F	
24.8	0.2214	45.2	0.398	80.3	0.394	98.2	0.272
41.2	0.302	75.3	0.541	116.6	0.608	137.5	0.475
74.9	0.319	112.6	0.644	174.8	0.87	205.0	0.826
101.1	0.342	172.2	0.6349	233.3	1.08	268.8	1.155
133.8	0.339	252.0	0.633	282.5	1.092	353.9	1.478
220.2	0.342	338.6	0.64	355.1	1.112	392.2	1.588
308.5	0.3398	432.2	0.648	444.4	1.09	435.0	1.685
422.5	0.3396	488.1	0.64	524.8	1.11	506.5	1.772
513.0	0.342						

TABLE 2—Smoothed Data—Solubility of *n*-Hexane in Water
(Mole Fraction C_6H_{14} x 10^4)

Pressure psia	100 °F	160 °F	220 °F	280 °F
	(5.04*)	(15.8*)	(38.51*)	(83.79*)
14.7	0.136	....	....	....
20.0	0.1855	0.0792	....	....
40.0	0.293	0.345	....	....
60.0	0.334	0.502	0.185	....
80.0	0.336	0.588	0.365	....
100.0	0.340	0.615	0.495	0.128
150.0	0.341	0.738	0.772	0.555
200.0	0.341	0.743	0.990	0.802
250.0	0.342	0.742	1.098	1.052
300.0	0.342	0.742	1.103	1.260
350.0	0.342	0.742	1.103	1.458
400.0	0.342	0.742	1.103	1.602
450.0	0.342	0.742	1.103	1.710
500.0	0.342	0.742	1.103	1.780

* Vapor pressure of pure *n*-hexane.

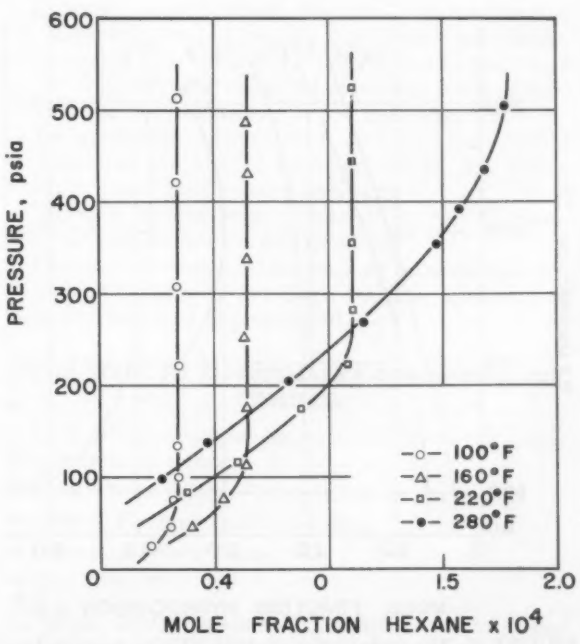


FIGURE 1—The solubility of n-hexane in water.

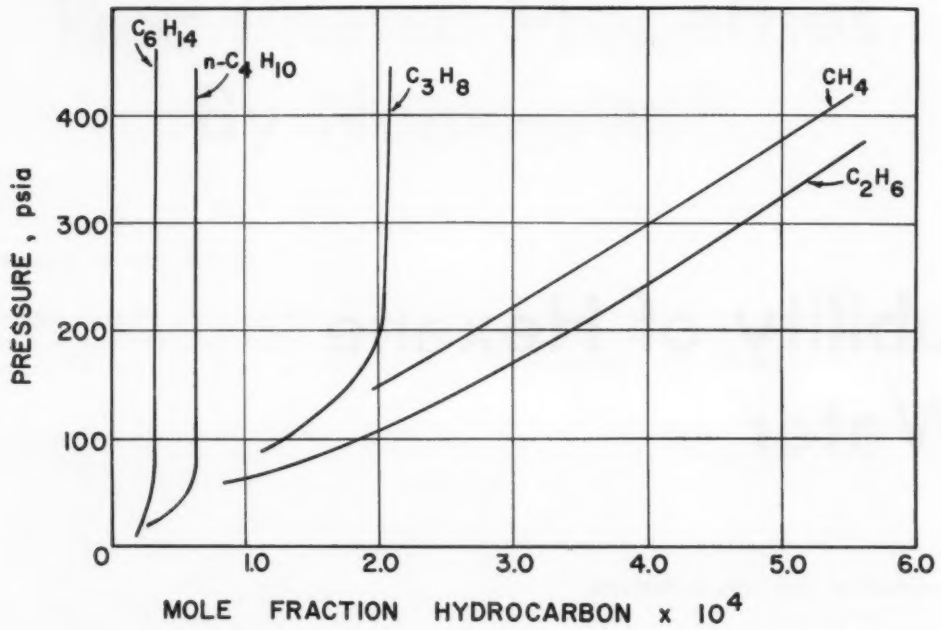


FIGURE 2—The comparative solubility of light hydrocarbons in water at 100° F.

diagram. From Figure 1, the smoothed data were obtained and are shown in Table 2.

Figure 2 shows the comparative solubilities of the various light hydrocarbons from methane to hexane at 100°F. A temperature-composition comparison of the solubilities of various hydrocarbons in water is shown in Figure 3.

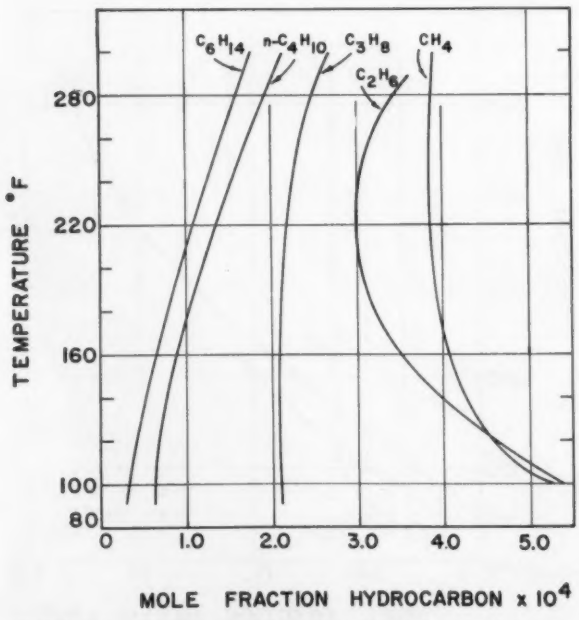


FIGURE 3—The comparative solubility of light hydrocarbons in water at 400 psia.

ACKNOWLEDGMENT

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Key Words for Indexing

Hexane
Liquid
Solubility
Vapor
Water

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Kudchadker

Dr. McKetta's biographical data appeared March 1961, p. 192.

Can Maintenance Be Measured and Controlled?

Every maintenance manager should accept this challenge and take steps to prove that he can measure, interpret and control maintenance operations

Ralph N. Price, Pittsburgh Plate Glass Co., Chemical Division, Corpus Christi, Texas

Maintenance has been defined, with some justification, as the art of the impossible. The gentleman who so blithely coined this phrase was probably thinking of maintenance managements' general acceptance of their inability to measure maintenance performance. This writer believes that every maintenance manager should accept this premise as a challenge and take steps to prove that he can measure, and interpret, a wide spectrum of maintenance operations.

For this discussion, let's think of "management control" as:

- The segment of management decision making which can be predicated primarily on factual, objective information.
- The establishment of performance standards for specific control areas and the evaluation of performance in these areas.

Authorization and planning control is combined because *most* maintenance work is a matter of *when* and *how* rather than a question of approval. There are, of course, enough exceptions to make authorization control of considerable importance.

BACKGROUND INFORMATION

The Corpus Christi plant of Pittsburgh Plate Glass Chemical Division was built in 1933 and 1934. Major products are soda ash, chlorine and caustic soda. This is a heavy chemical, continuous process plant which is fully automated. When key equipment is down, production loss is heavy.

Total plant employment approximates 750 people; 250 are in maintenance. The Maintenance Department is responsible for non-routine maintenance; custodial and other services, and most of the routine jobs such as truck driving, tool room personnel, storeroom, etc. Non-routine maintenance operations (which include repetitive mechanical repairs and production cleaning) account for roughly 60 percent of the man-hours worked by maintenance people. Approximately 50 job requests for non-routine work are received each working day. These requests will average in the neighborhood of 20 manhours per job.

With this in mind, most A&P control levels are determined by the size of the job in man-hours. Practically all mechanical repair work and small building maintenance jobs are controlled on this basis.

Large building maintenance jobs, such as major painting and structural replacements, receive careful top level consideration. On these jobs we ask:

- Is this the optimum time to do the work?
- What are the most economical materials to use?

Housekeeping standards are often an important consideration on jobs in this category. Generally the production superintendent's signature is required.

Expensed improvements, (or minor rearrangements or additions) are, of course, completely controllable. When a job is so classified, it is estimated in labor and material dollars and submitted at various levels of production, or top, management for final approval.

To summarize, authorization and planning control is based on the size of the job and/or the source characteristic. "Size" control levels are:

Through 16 man-hours—"control" or area foreman.

17-60 man-hours—general foremen.

Over 60 man-hours—Maintenance Superintendent—"Customer" approval on large building maintenance jobs and expensed improvements.

FOUR STEPS TO MAINTENANCE ADMINISTRATIVE CONTROL

Let's break administrative control down into four major areas, as follows:

- Work Order System—the mechanism for control.
- Central Planning and Scheduling.
- Control of Work Force.
- Cost Control.

1. Work Order System. If control means to "measure and interpret," a good work order system is a basic mechanism for the measurement process. A written job

request is required on all non-routine work. The job request is converted into a work order if estimated over 16 man-hours; or for any size job which is designated an emergency, a safety order, or covers mechanical repairs to production equipment. Every job request, and consequently all work orders, are estimated in craft man-hours. A variety of information is coded into each maintenance work order. Job orders are only a memorandum record and no final accounting is made of these small jobs. However, about 85 percent of the non-routine man-hours are charged to a maintenance work order number.

2. Central Planning and Scheduling. Central planning and scheduling was established in our plant early in 1956. Planning (and estimating) is handled by two "planners" with help from the craft foremen and the project engineers. As mentioned, each job is estimated in craft man-hours—and the complex jobs are programed. The chief planning and scheduling engineer is responsible for compiling a detailed daily work schedule for each craft. This schedule includes only the jobs estimated over 16 man-hours, but covers about 80 percent of the man-hours expended on non-routine operations. The smaller jobs are largely handled by area (multicraft) supervisors, although each craft foreman usually has a small backlog of such jobs. The craft foremen use the smaller jobs to fill out a day's work when a scheduled job is finished early, or when a scheduled job falls through unexpectedly.

The chief P&S engineer also compiles a weekly "top priority list" and a 90-day forecast covering the larger and more important jobs. The 90-day forecast is updated weekly.

If we accept the premise that the large majority of requests for maintenance services are entirely justified, then the matter of *when* is a key decision. We consider the primary job here is "doing first things first." The priority system we use has worked very well.

Compliance with the daily schedule is considered important, but we do not expect or want—100 percent compliance. The schedule should not be a mandate to the front line supervisors because even the best planning often falls apart after a job is started. The control foremen (front line supervisors) should have the ability and the authority to make necessary changes in the field.

3. Control of Work Force. Control of work force, or the balancing of work force and workload, is probably the most important part of maintenance administrative control. In this field we have to consider our needs of today, for next week, and for next year. To have enough well-trained mechanics to take care of any reasonable emergency without being over-manned at other times is a real challenge.

To help maintain workloads at a reasonable level, we use a variety of feed-back statistics. These include a weekly total of work backlog expressed in man-hours, and broken down by priorities, for each craft group. We are also furnished a tabulation of the new work which came into the department during the week—also broken down by crafts. These statistics are accumulated from the maintenance work orders by data processing equipment. Obviously, the workload statistics are only as reliable as our estimating. However, on a department-wide basis the net estimating error is usually under 5 percent, so the backlog figures are reasonably accurate. The gross estimating error usually runs around 30 percent.

An optimum backlog is considered to be 25 days of work for the men who are primarily engaged in non-routine maintenance work. This is not entirely an arbitrary figure, as we started out with 15 days; went to 20 days and then to 25 days. We found, mostly by trial and error, our greatest flexibility and most efficient operations to be about the 25 days level.

Management has always recognized social and ethical responsibilities to our employees, so stability of employment is of primary concern. Some years ago, it became evident a better method was needed for keeping work force and workload in balance. An Operations Research approach to this problem turned up a rather surprising answer. It was determined, to our satisfaction at least, that the best operation under good sales conditions is to work 5 percent planned overtime. Under this concept, adjustments can be made to below average sales conditions without a layoff, and this is also an ideal way to maintain adequate craft balance.

4. Cost Control. The phrase "cost control" as applied to maintenance operations is rather difficult to define. In the first place, it is fairly obvious that if control is good, then costs should automatically fall in line. If, as we suspect is the case in many instances, cost control really means "cost consciousness" then this isn't a matter of control but rather a state of mind. Probably the same basic thought is expressed when "cost control" is considered synonymous with "budgetary control." In the heavy process industry, at least, maintenance is more nearly a fixed than a variable cost, so budgets must be based on intuitive, or empirical, values. Most maintenance budgets are therefore just a vehicle to promote cost consciousness.

We also put little dependence on some of the other yardsticks which are widely used. We do not believe that the application of predetermined work standards is a satisfactory measurement of maintenance effectiveness; and maintenance costs expressed as a ratio of production, are not considered reliable indicators. Only a small portion of the total maintenance effort has a relationship to production.

To sum up, we do not think budgets, predetermined work standards, or maintenance costs expressed as a percent of production, are useful as maintenance controls. Yardsticks of this nature, which are not automatically adjusted to contemporary technology and concepts, might even lead to complacency.

As we haven't been able to establish an optimum level for maintenance, cost trends are watched very

closely. Most of our statistics are expressed in total man-hours (or dollars) unless there has been significant expansion in a given cost center. We suspect the problems of maintenance are a composite of every job we do. However, as it is impractical to analyze each job separately, we break maintenance cost down into various classifications—(or source characteristics). It isn't much help to find out that total maintenance costs are going up in a given plant area. When, however, maintenance expenditures are broken down by the type of work performed, critical areas are relatively easy to spot. For example, if a big improvement job raised maintenance costs in a producing cost center, this is not maintenance responsibility. If, on the other hand, mechanical repairs are trending upward, we take a look to be sure we are not overmaintaining; or conversely if preventive maintenance has been lagging.

Job Execution Control. The responsibility for the execution of every job should be clearly defined. As already mentioned, most of the small mechanical jobs are handled by multicraft supervisors who work in a given area. The area supervisors are assigned 8 to 10 men from the various crafts on a weekly basis and take care of the small, mostly noncraft, jobs in each area. The area supervisor is responsible for planning, scheduling, and material procurement for his work.

Outside of the areas, and for the general run of maintenance jobs, a "control foreman" is appointed. The control foreman is generally the craft foreman whose men carry the major portion of the job. The control foreman is responsible for the administrative phases of his jobs, but does not supervise crafts other than his own. The job request (or maintenance work order) is addressed to the control forman, he sees the job is ready, is cleaned up, and he is responsible for the closing out paper work when the job is finished.

On many large jobs, especially those with high activity rates and a variety of crafts, we appoint a "job superintendent." The job superintendent acts as a multicraft supervisor and is responsible for all phases of any job for which he carries this responsibility. The job superintendents are usually craft foremen, but sometimes a capable staff man serves in this capacity. The job superintendent is relieved of other supervisory duties for the duration of his responsibilities as a job superintendent.

A "project control engineer" is assigned to a limited number of jobs. These are generally construction or large building maintenance jobs which are extended over a period of time with widely varying activity rates. The project control engineer acts as coordinator on an assigned project, furnishes feed-back information to central planning and scheduling, hustles material, and helps the job superintendent or control foreman in any way he can. Jobs of this size and nature are generally broken down into phases. "Supplemental" orders carrying the same number are issued on a step-by-step basis. This is done so as not to inflate the workload; so the planning for each step can be shown on the work order, and for control purposes. The project control engineer is responsible for handling this paper work. He also helps plan each "phase" of the job.

We pin down the responsibility for the procurement of materials on every job. It is generally assumed ordinary supplies are obtainable from the storeroom, but availability of critical material must be determined before the job is ready for scheduling. The control foreman is generally responsible, but sometimes this is assigned to a staff man. As there is no magic wand that can be waved to procure material the assigning of this as a definite responsibility is important.

Preventive Maintenance. Much of the producing equipment in our plant is included in a preventive maintenance program. We have no formula for this, but have somewhat arbitrarily excluded from the PM program electric motors under 50 hp and pumps driven by motors of 25 hp and under. Everything else is included.

A full-time engineer is assigned to this important function and, for the last several years, erratic maintenance on equipment covered by preventive maintenance averaged about 5 percent of the hours worked on this equipment. This is probably about as good as we can afford.

Our preventive maintenance philosophy is quite a bit different from some we read about. Very litle money is spent on routine inspections, and there are very few fixed cycles. We try to keep the PM program flexible and dynamic; to extend cycles by corrective maintenance and by better forecasting. Most PM overhauls are predicted from one job to the next on the basis of the complete historical records which are kept on each piece of equipment.

The predictions are qualified by current conditions and the importance and type of the equipment in question. For example, the gears in a herringbone gear reducer that has a bearing failure are usually ruined and the resultant costs are relatively very high. On the other hand, a pump covered by PM can run to failure without inflating maintenance costs, so interruption to production is the primary consideration.

Storeroom Control. Although the storeroom serves the entire plant, it is primarily a maintenance operation, so is included in the maintenance organization. All material is disbursed by a storeroom delivery system which will average 80 deliveries a day covering approximately 250 commodities.

Storeroom control problems break down like this:

- Control of mechanical and electrical space parts inventory.
- Control of supplies.
- Control of stockouts.
- Cost control.

Spare parts control is exercised by a committee composed of the maintenance superintendent, production superintendent, storeroom manager, mechanical general foreman, and the PM engineer. When a spare part is used, assuming stock is reduced to a predetermined "order point," the traveling requisition is pulled and forwarded to the PM engineer. He works up a case history on the equipment for which the spare part ap-

plies, and makes a recommendation for consideration by the committee.

When decisions on spare parts are based on complete historical data the procurement of a spare part can often be deferred for any time from six months to ten years. The production superintendent has a strong voice in decisions of this nature, but generally complete agreement is reached. Currently, we have $200,000 worth of spare parts tickled for purchase at some later date. This is an integral part of the PM program and is not feasible unless complete historical records are available.

Control of Supplies. Supplies and material, which move with some regularity, are ordered by a formula which takes into account unit and lot costs, turnover, procurement time, and a protection rate which is expressed in "stockouts per unit of time." Requisitions for material of this nature can be handled by a clerk with management exercising control by being able to change protection rates.

Commodities with a unit price of $1 or less which are bought in lots of $50 or less are charged out "direct." These items are handled like any other commodity in the Storeroom except no inventory accounting is done. When this change was made some years ago, clerical work in the Storeroom was reduced 50 percent, but only 10 percent of the disbursements (in dollars) was affected. Most of the ordering of these commodities is done on a scheduled basis by groups of similar items (pipe fittings, bolts, etc.).

Two types of stockouts are considered in the control procedures. A "book" stockout is recorded when a commodity ledger reads zero. By averaging the protection rates for the commodities which are ordered by formula it can be determined how many book stockouts there should be for a given period of time. This figure is used as an optimum in evaluating the effectiveness of inventory control.

An "actual" stockout is counted when there is a call for material or supplies which cannot be completely filled. An optimum number of actual stockouts should be determined by establishing a balance between time lost in the field and the inventory needed to hold actual stockouts at a predetermined level. Currently, actual stockouts at our plant average about three per working day. From an economic standpoint this is probably on the low side. However, as the unavailability of material has such a bad effect on the man in the plant, we have accepted this as a reasonable figure.

Performance. The evaluation of various segments of maintenance performance has been implicit in most of the previous discussions. In addition, we have several reasonably objective methods for making quantitative evaluations of other elements of maintenance performance. These elements can be grouped under three general headings:

- Individual performance.
- Group performance.
- Administrative (or management) performance.

Individual performance evaluation is mentioned merely to point out that we have no incentives of any kind and make no attempt to measure individual performance. Most routine jobes are programed to make sure the people involved are kept reasonably busy. In this field it is the semi-routine, or erratic (or waiting line) (or queuing) jobs which are the real challenge.

Work sampling is used as a primary tool for measuring group, or craft, work effort. In addition, a performance rating system for measuring management effectiveness at the craft level was recently devised. Besides giving management a reasonably objective answer as to the relative performance of the various craft foremen, this information is considered important for motivational reasons. As a matter of fact, the craft performance rating system was originally conceived to serve as a "motivational display."

A performance rating system, using 20 parameters, was designed to compare over-all maintenance performance against theoretical "perfect" performance. The 20 indicators are grouped under five major control areas with some indicators being used more than once. This system is based entirely on statistics and the only intuitive judgments used were in setting ideals, and weights, for each of the parameters. The results of each parameter are combined on a weighted basis to give a maintenance proficiency index expressed as a percent of perfect performance.

An attempt is being made to establish an optimum level for preventive maintenance. So far, this is a more or less shot in the dark, but it is believed will eventually lead to some good answers.

One final word. Most of this discussion has been built around specifics based primarily on quantitative evaluations. We have no illusions about having successfully transposed management from an art to a science, and believe that good judgment and creative imagination are still among the most important characteristics of a successful manager.

Key Words for Indexing

Authorization	Preventive Maintenance
Control	Scheduling
Costs	Spares
Maintenance	Standards
Measurement	Stores
Orders	Workload
Performance	Work Sampling
Planning	Work Simplification

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Figure Separations This New Way

Part 5 – A Convergence Method for Absorbers
Part 6 – Minimization of Round-Off Errors
Part 7 – Absorbers With Reboilers

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Separation problems in existing absorbers can also be solved by the rapid convergence method, extended from Parts 1-4. This Θ-method of convergence makes the digital computer a powerful tool for solving multicomponent problems.

An analogous treatment may be employed for strippers. No assumptions other than those called for by perfect plates are made. The effect of round-off error is considered and a procedure for minimizing it is given. The higher rate of convergence obtained by use of bubble points instead of dew points in the calculational procedure is demonstrated by the solution of a wide variety of numerical examples.

Three general types of specifications are given for absorbers. In each case, compositions of the lean gas and rich oil are sought. In the first the total liquid and vapor rates for each plate are fixed at a preselected set of values. In the second, the total liquid and vapor rates throughout the column are taken to be those computed by use of a combination of the Θ-method and material balances. In the third type of specification, the vapor and liquid rates throughout the column are determined by enthalpy balances. Also, a treatment for single-phase components is presented and demonstrated by a numerical example.

In addition, the results of further investigations of enthalpy balances are presented. A procedure, referred to as the "Q-method," for making enthalpy balances is introduced. This procedure makes use of intercoolers (or heaters) as required to maintain the flow rates throughout the column within specified limits. Also an improved procedure which is called the "constant-composition" method for the calculation of stream enthalpies is applied to absorbers.

The material balance equations are similar in form to those given by Franklin and Horton,[21] Kremser,[23] Souders and Brown,[25] and Thiele and Geddes.[18] In general the approach to absorbers is similar to that proposed previously for distillation columns. For example, in the third set of specifications which is treated is a subsequent section, the following are specified: the number of plates, the operating pressure, and the rate of flow of the rich gas, lean oil, and lean gas streams. Furthermore, the compositions of the lean oil and rich gas as well as the enthalpy (or temperature) of one of these are specified. The temperature or enthalpy of the other

Did You Miss These?

This series develops a new convergence method which makes the digital computer a powerful tool for handling separation problems. Previous parts were:

Part 1—New Convergence Method Will Handle Many Cases, PR, June 1959, p. 221.

Part 2—Product Purity Can Set Conditions for Column, PR, July 1959, p. 151.

Part 3—Consider Multi-Feed Columns With Side Streams, PR, October 1959, p. 139.

Part 4—Explore Operating Characteristics of a Column, PR, August 1960, p. 121.

is determined by an enthalpy balance. On the basis of assumed L/V and temperature profiles, the molal rates of flow of all components throughout the column are calculated by material balances and equilibrium relations. By use of these results and the convergence method, the compositions of the vapor and liquid streams leaving each plate and the corresponding corrected temperature profile are obtained. Then the total molal flow rates of vapor and liquid throughout the column are calculated by use of enthalpy balances. The entire procedure is repeated until successive temperature profiles show satisfactory agreement. Application of the equations to strippers is similar to that described for absorbers.

MATERIAL BALANCES

In the following treatment, the plates of the absorber are numbered from the top down; the top plate is assigned the number 1 and the bottom plate the number N. The lean oil entering the top plate is denoted by the subcript "zero," and the rich gas entering the N'th plate by the subscript N + 1. In this treatment, the components are numbered in the order of decreasing volatility. The most volatile is given the number 1 and the least volatile component (usually the principal component of the lean oil) the number c, where c is also the total number of components. Material balances may be written around either the top or the bottom of the column and any given plate. As discussed in the next section, the set of material balances which gives the smallest round-off error is employed. For any component i appearing in both phases, a material balance around the top of the absorber and plate j - 1 is represented by

$$\frac{v_{ji}}{v_{1i}} = A_{j-1,i}\left(\frac{v_{j-1,i}}{v_{1i}}\right) + 1 - \frac{l_{oi}}{v_{1i}}, \quad 2 \leqq j \leqq N+1 \quad (1)$$

where,

$A_{ji} = \dfrac{L_j}{K_{ji}V_j}$, the absorption factor for component i at plate j.

The absorption factor relates the moles of component i in the vapor and liquid (taken to be in equilibrium) leaving plate j, that is, $l_{ji} = A_{ji}v_{ji}$. Equation (1) may be used for the calculation of the flow rates for each plate, provided v_{1i} is known. The quantity $(1-l_{oi}/v_{1i})$ may be computed by formulas which are developed as follows. Repeated substitution of the expression for v_{ji}/v_{1i} into the one for $v_{j+1,i}/v_{1i}$ as given by Equation (1) yields

$$\frac{v_{N+1,i}}{v_{1i}} = \omega_i + \Omega_i\left(1 - \frac{l_{oi}}{v_{1i}}\right) \quad (2)$$

where,

$$\omega_i = A_{Ni}A_{N-1,i}\cdots\cdots A_{2i}A_{1i}$$

$$\Omega_i = 1 + A_{Ni} + A_{Ni}A_{N-1,i} + \cdots\cdots + A_{Ni}A_{N-1,i}\cdots\cdots A_{3i}A_{2i}$$

An over-all material balance may be written as follows:

$$1 + \frac{l_{Ni}}{v_{1i}} = \frac{l_{oi}}{v_{1i}} + \frac{v_{N+1,i}}{v_{1i}} \quad (3)$$

Solving Equations (2) and (3) for l_{Ni}/v_{1i} yields

$$\frac{l_{Ni}}{v_{1i}} = \frac{\omega_i l_{oi} + (\Omega_i + \omega_i - 1)\, v_{N+1,i}}{\Omega_i l_{oi} + v_{N+1,i}} \quad (4)$$

After l_{Ni}/v_{1i} has been calculated by use of Equation (4), the quantity $(1 - l_{oi}/v_{1i})$ is readily computed by use of Equation (3). Then the v_j's (or l_j's) are calculated in a stepwise fashion from the top of the column to the bottom.

For any two-phase component, a material balance around the bottom of the column and any given plate may be represented by

$$\frac{l_{j-1,i}}{l_{Ni}} = S_{ji}\left(\frac{l_{ji}}{l_{Ni}}\right) + 1 - \frac{v_{N+1,i}}{l_{Ni}}, \quad 1 \leqq j \leqq N \quad (5)$$

where,

$S_{ji} = \dfrac{K_{ji}V_j}{L_j}$, stripping factor for component i at plate j.

In a manner similar to that shown for Equation (4), the following expression is obtained.

$$\frac{l_{Ni}}{v_{1i}} = \frac{l_{oi} + \Phi_i v_{N+1,i}}{(\Phi_i + \phi_i - 1)\, l_{oi} + \phi_i v_{N+1,i}} \quad (6)$$

where,

$$\phi_i = S_{1i}S_{2i}\cdots\cdots S_{N-1,i}S_{Ni}$$

$$\Phi_i = 1 + S_{1i} + S_{1i}S_{2i} + 2_{1i}S_{2i}S_{3i} + \cdots + S_{1i}\cdots S_{N-1,i}$$

After l_{Ni}/v_{1i} has been computed by Equation (6), the term $(1 - v_{N+1,i}/l_{Ni})$ is readily evaluated by an over-all material balance. Then Equation (5) may be applied for the calculation of the l_j's (or v_j's) from the bottom to the top of the column.

EFFECT OF ROUND-OFF ERROR

Since it can be proved that Equations (1) and (5) give exactly the same value for any vapor rate (v_{ji}), any difference obtained during the course of the calculations may be attributed to round-off error. The decision of whether to make calculations up from the bottom (Equation (5)) or down from the top (Equation (1)) may be made on the basis of the one which gives the smallest round-off error. Equations (4) and (6) may also be shown to be equivalent. These proofs are presented in

the Appendix. In order to demonstrate the effect of round-off error, several relatively simple problems were solved. The results are shown in Table 1.

For all cases considered, it was found that Equations (4) and (6) gave values of l_{N1}/v_{11} equal to within seven or eight digits out of a possible eight. As a basis for comparison of the round-off errors given by Equations (1) and (5), the quantity l_{N1}/v_{11} was computed by the successive application of each equation from one end of the column to the other. The value so obtained was divided by the one calculated by Equation (4) (or Equation (6)). These ratios are shown in Table 1. These results permit the statement of certain conclusions.

When a component enters in V_{N+1} but not in L_o, the most accurate flow rates are obtained by making calculations down from the top of the column by use of Equation (1). This results from the fact that for this case $(1 - l_{oi}/v_{1i})$ is equal to unity. Round-off error was found to occur when this term was negative.

Conversely, when a component enters in L_o but not in V_{N+1}, the application of Equation (5) gives the most accurate rates throughout the column for the given component. However, when components enter in both V_{N+1} and L_o, the most accurate method of calculation is not so easily deduced in advance. For such components, it is recommended that both equations be applied for two or three trials. The equation giving the most accurate results may be selected by the ratio test as shown in Table 1.

It should be pointed out that the round-off error obtained by use of A's of 0.1 and 10 is less than that which can generally be expected. To demonstrate the effect of the precise number (correct to eight digits) on the round-off error, case 11 was solved, which is to be compared with case 7. Also, for the special case of $A = 1$, no round-off error was obtained by use of either of the equations.

METHOD OF CONVERGENCE

The proposed convergence method is an extension of the Θ-method, presented in Parts I and II for conventional distillation columns. Corresponding to the specification of the distillate rate for conventional distillation columns, the total moles of lean gas V_1 (or the rich oil rate L_n) are fixed. In all of the calculational procedures for the various types of specifications presented herein, the compositions on each plate are altered in a manner which reflects the deviation between the calculated and specified values of V_1. The corrected sets of compositions are calculated as follows:

$$y_{ji} = \frac{\left(\frac{v_{ji}}{v_{1i}}\right)_{ca}(v_{1i})_{co}}{\sum_{i=1}^{c}\left(\frac{v_{ji}}{v_{1i}}\right)_{ca}(v_{1i})_{co}} \quad \text{and} \quad x_{ji} = \frac{\left(\frac{l_{ji}}{l_{Ni}}\right)_{ca}(l_{Ni})_{co}}{\sum_{i=1}^{c}\left(\frac{l_{ji}}{l_{Ni}}\right)_{ca}(l_{Ni})_{co}} \tag{7}$$

where all of the components appear in both the vapor and liquid phases. The treatment of single-phase components is given in a subsequent section. The calculated values of v_{ji}/v_{1i} are computed by Equation (1). The corrected v_{1i}'s calculated by Equation (10) are both in material balance and in agreement with the specified value of V_1. As shown in the Appendix, the ratio of $(v_{1i})_{co}$ to $(l_{Ni})_{co}$ may be related to the corresponding ratio obtained from the material balance equations by use of a single multiplier as follows:

$$\left(\frac{l_{Ni}}{v_{1i}}\right)_{co} = \Theta_o\left(\frac{l_{Ni}}{v_{1i}}\right)_{ca} \tag{8}$$

The expression for $(v_{1i})_{co}$ may be obtained by an overall component material balance. Since by definition the

TABLE 1—Round-Off Error Given by Different Calculational Procedures for Absorbers
(For all cases shown N = 10 and A remains constant throughout the column.)

Case No.	l_o and v_{N+1}	Absorption Factor A	Top to Bottom (l_N/v_1) stepwise by Eq. (1) (l_N/v_1) formula*	Bottom to Top (l_N/v_1) stepwise by Eq. (5) (l_N/v_1) formula*
1	$l_o = 0$**	0.1	1.0000	0.9000
2	$l_o = 0$	10.0	1.0000	0.9000
3	$v_{N+1} = \frac{l_o}{2}$	0.1	1.0000	2.9000
4	$v_{N+1} = l_o$	0.1	1.0000	1.9000
5	$v_{N+1} = 2l_o$	0.1	1.0000	1.4000
6	$v_{N+1} = 0$	0.1	1.1111	1.0000
7	$v_{N+1} = 0$	10.0	1.1111	1.0000
8	$v_{N+1} = \frac{l_o}{2}$	10.0	0.7143	1.0000
9	$v_{N+1} = l_o$	10.0	0.5263	1.0000
10	$v_{N+1} = 2l_o$	10.0	0.3448	1.0000
11	$v_{N+1} = 0$	9.9999999	−109.999	1.0000
12	$v_{N+1} = l_o$	1.0	1.0000	1.0000

* Value of (l_N/v_1) given by Equation (4) (or Equation (6)).
** Component enters the column only in v_{N+1}.

corrected values of the v_1's satisfy a component material balance, it follows

$$v_{N+1,1} + l_{o1} = (v_{11})_{co}\left[1 + \left(\frac{l_{N1}}{v_{11}}\right)_{co}\right] \quad (9)$$

When the ratio $\left(\frac{l_{N1}}{v_{11}}\right)_{co}$ in this expression is replaced by its equivalent as given by Equation (8), the expression for $(v_{11})_{co}$ is obtained.

$$(v_{11})_{co} = \frac{v_{N+1,1} + l_{o1}}{1 + \Theta_o\left(\frac{l_{N1}}{v_{11}}\right)_{ca}} \quad (10)$$

The quantity Θ_o is the positive root of the function $g_o(\Theta_o)$, where

$$g_o(\Theta_o), = \sum_{i=1}^{c} (v_{1i})_{co} - V_1 \quad (11)$$

The calculation of Θ_o by use of Equation (11) may be effected in several ways. Two of these, Newton's method and interpolation *(regula falsi)*, were discussed in Part I. It is to be observed that when the desired value of Θ_o has been obtained, the corrected v_{1i}'s are given by Equation (10). These values are used in Equation (7) for calculation of the compositions which are in turn employed in the calculation of a corrected temperature profile. If instead of specifying V_1, a sum of v_1's is specified, the extension is analogous to that shown in Part II. The value of Θ_o to be employed in Equation (10) is the positive root which give $g_o(\Theta_o) =$, where

$$g_o(\Theta_o) = \sum_{i=1}^{s} \frac{v_{N+1,i} + l_{oi}}{1 + \Theta_o\left(\frac{l_{Ni}}{v_{1i}}\right)_{ca}} - \sum_{i=1}^{s} v_{1i} \quad (12)$$

It is to be noted that the second summation on the right-hand side of Equation (12) is the specified quantity.

SINGLE-PHASE COMPONENTS

A component which is present in the gas phase alone is referred to as a single-phase light component. Similarly, if a component appears only in the liquid phase, it is called a single-phase heavy component. Certain components such as helium or steam are generally considered truly single-phase components. Others are sometimes treated in this manner because of the lack of data.

In order to demonstrate the treatment for both single-phase light and heavy components simultaneously, it is supposed that the rich gas entering the column contains some single-phase light components and that the entering lean oil contains one or more single-phase heavy components. In the following equations, the single-phase light component (or components) is given the component number 1 while the single-phase heavies are denoted by c. The material balance equations stated previously are applicable for the distributed components; whereas, for components 1 and c, the flow rates throughout the column are equal to the corresponding terminal values. When intercoolers (or interheaters) are employed for each plate, it is possible to operate at any reasonable set of specified flow rates throughout the column as discussed in a subsequent section. The Θ-method of convergence for this system consists of the application of the following set of equations. The development of these equations is given later.

$$y_{j1} = \left(\frac{V_j - v_{j,1}}{V_j}\right)\frac{\left(\frac{v_{j1}}{v_{11}}\right)_{ca}(v_{11})_{co}}{\sum_{i\neq 1,c}\left(\frac{v_{j1}}{v_{1i}}\right)_{ca}(v_{1i})_{co}}, i \neq 1, c \quad (13)$$

$$y_{j,1} = \frac{v_{j,1}}{V_j} \quad (14)$$

$$x_{j1} = \left(\frac{L_j - l_{j,c}}{L_j}\right)\frac{\left(\frac{l_{j1}}{l_{N1}}\right)_{ca}(l_{N1})_{co}}{\sum_{i\neq 1,c}\left(\frac{l_{j1}}{l_{N1}}\right)_{ca}(l_{N1})_{co}}, i \neq 1, c \quad (15)$$

$$x_{j,c} = \frac{l_{j,c}}{L_j} \quad (16)$$

$$(v_{1i})_{co} = \frac{v_{N+1,i} + l_{oi}}{1 + \Theta_o\left(\frac{l_{Ni}}{v_{1i}}\right)^{ca}}, i \neq 1, c \quad (17)$$

$$g_o(\Theta_o) = \sum_{i\neq 1,c}\frac{v_{N+1,i} + l_{oi}}{1 + \Theta_o\left(\frac{l_{Ni}}{v_{1i}}\right)^{ca}} - (V_1 - v_{1,1}) \quad (18)$$

Although the rates of flow of the nondistributed components are generally constant throughout the column (for columns in which streams are introduced and withdrawn only at the ends), the subscript j was retained in Equations (13) through (16) for the sake of generality. When the V_j's and L_j's are all unknown except for the specified values of the terminal flow rates, V_1, V_{N+1}, L_o and L_N, is recommended that the unknown rates in the expressions for the mole fractions be estimated by use of the following formulas:

$$V_j = \sum_{i\neq 1,c}\left(\frac{v_{j1}}{v_{11}}\right)_{ca}(v_{11})_{co} + v_{j,1} \quad (19)$$

$$L_j = \sum_{i\neq 1,c}\left(\frac{l_{j1}}{l_{N1}}\right)_{ca}(l_{N1})_{co} + l_{j,c} \quad (20)$$

However, the values of V_j and L_j to be employed in the calculation of the A_j's and S_j's may be calculated and selected in different ways as discussed in the next section which is concerned with various types of specifications.

CALCULATIONAL PROCEDURES

In each of the specifications presented, it is supposed that in addition to the variables mentioned, the number of plates, the composition and rate of flow of lean oil and the rich gas and the column pressure are also fixed.

1. Specifications: *(1) V_1 (or L_N), (2) T_o and T_{N+1} and (3) a Fixed Set of L's and V's for the Column.*

The calculational procedure for this set of specifications follows very closely that proposed previously for a conventional distillation column in which the molal overflows are fixed throughout the column. On the basis of an assumed temperature profile, the quantities needed for the caluculation of a corrected set of compositions as given by Equations (13) through (18) are computed by use of Equations (1) through (5). Use of these compositions permits the calculation of a corrected temperature profile as described in the next section. The A_{ji}'s and S_{ji}'s for each trial are evaluated on the basis of the specified set of L_j's and V_j's and the K_{ji}'s obtained from the assumed temperature profile for the given trial. When the calculated and the specified values of V_1 as well as the temperature profiles between successive trials are in agreement, a solution has been obtained. The intercooler duty required for each plate in order to operate at the specified set of flow rates is given by an enthalpy balance around each plate as follows:

$$Q_{cj} = V_{j+1}H_{j+1} + L_{j-1}h_{j-1} - V_jH_j - L_jh_j \quad (21)$$

The enthalpies of the vapor and liquid streams may be calculated as indicated in Part I.

2. Specifications: *(1) V_1 (or L_N), (2) T_o and T_{N+1} and (3) the Set of L's and V's Given by Material Balances.*

For this second set of specifications, the calculational procedure is the same as that outlined for the first set of specifications except that the A_{ji}'s and S_{ji}'s for each trial are calculated on the basis of the L_j's and V_j's obtained by material balances. That is, except for the terminal rates which are specified, the L_j's and V_j's to be employed in the A_{ji}'s and S_{ji}'s are computed by use of Equations (19) and (20). When convergence is obtained, the intercooler (or heater) duty for each plate is computed by use of Equation (21).

3. Specifications: *(1) V_1 (or L_N), (2) T_o (or T_{N+1}) and (3) the Set of L's and V's Given by Enthalpy Balances.*

For both adiabatic and non-adiabatic operation, procedures are presented for the calculation of the vapor and liquid rates throughout the column. Adiabatic operation as used herein means that the intercooler (or heater) duty for each plate is zero. Except for the differences in the procedures for the determination of the L_j's and V_j's to be employed in the A_{ji}'s and S_{ji}'s, the general calculational procedure is the same as that outlined in Specification 2.

Adiabatic Operation. After any trial calculation through the column, the unknown inlet temperature T_{N+1} (or T_o where T_{N+1} is specified) is determined by an over-all enthalpy balance. Then the vapor and liquid flow rates for each plate throughout the column are calculated by use of enthalpy and material balances which include either the top or the bottom of the column and each plate. This procedure is analogous to that described in Part I for conventional columns.

Also, in a manner similar to that shown in Part I, restrictions were placed on the variation of the vapor rates used to make successive trial calculations through the column. This procedure which assumes $Q_{cj} = 0$ for all j cannot be expected to converge to a solution if it is impossible to operate each plate adiabatically. When enthalpies were calculated by Equations (20) and (21) of Part I, many absorber problems did not appear to be adiabatically feasible. However, some were found to have adiabatic solutions when the stream enthalpies were calculated by the method which follows. Since Mr. J. T. Kurzeja, Dr. Ralph Cecchetti and Mr. R. H. Johnston (Esso Research and Engineering Company) found this procedure to be superior to Equations (20) and (21) of Part I for conventional columns, it was applied to absorbers.

The procedure given in Part I is referred to as the "conventional" method and the one presented herein is called the "constant-composition" method for the calculation of enthalpies. This name was selected because of the interpretation which may be given to the enthalpy differences appearing in Equation (22). For example, the term $[H(x_j)_{j+1} - h_j]$ represents the difference between the enthalpy of one mole of vapor at the temperature T_{j+1} and one mole of liquid with the same composition at the temperature T_j. All of the enthalpy differences appearing in Equation (22) may be interpreted as thermodynamic processes which occur at constant composition.

In the constant-composition method, the term $V_{j+1}H_{j+1}$ of the enthalpy balance around the top of an absorber and plate j is replaced by the following expression

$$L_j \sum_{i=1}^{c} H_{j+1,i}x_{ji} + V_1 \sum_{i=1}^{c} H_{j+1,i}y_{i1} - L_o \sum_{i=1}^{c} H_{j+1,i}x_{oi}$$

which is developed in the following manner. When convergence is obtained the corrected flow rates for all components are in material balance. Thus the above expression is identically equal to $V_{j+1}H_{j+1}$; that is

$$V_{j+1}H_{j+1} = \sum_{i=1}^{c} H_{j+1,i}v_{j+1,i} = \sum_{i=1}^{c} H_{j+1,i}\left(l_{ji} + v_{i1} - l_{oi}\right)$$

Use of the alternate expression for $V_{j+1}H_{j+1}$ in an enthalpy balance around the top of an absorber and any plate j yields

$$L_j = \frac{V_1 [H_1 - H(y_1)_{j+1}] + L_o [H(x_o)_{j+1} - h_o]}{[H(x_{j\,j+1} - h_j]}$$
$$1 \leqq j \leqq N-1 \qquad (22)$$

where,

$$H_1 = \sum_{i=1}^{c} H_{1i} y_{1i} \quad , \quad H(x_o)_{j+1} = \sum_{i=1}^{c} H_{j+1,i} x_{oi}$$

$$H(y_1)_{j+1} = \sum_{i=1}^{c} H_{j+1,i} y_{1i} \quad , \quad H(x_j)_{j+1} = \sum_{i=1}^{c} H_{j+1,i} x_{ji}$$

$$h_o = \sum_{i=1}^{c} h_{oi} x_{oi} \quad , \quad h_j = \sum_{i=1}^{c} h_{ji} x_{ji}$$

After L_j has been determined by Equation (22), the vapor rate for plate j + 1 is given by the material balance,

$$V_{j+1} = V_1 + L_j - L_o \quad , \quad 1 \leqq j \leqq N-1 \qquad (23)$$

The Q-Method for Making Enthalpy Balances. When adiabatic operation is impossible at the given set of specifications, a solution may be obtained by use of a suitable arrangement of intercoolers (or heaters). Actually, once it is agreed to employ an array of intercoolers (or heaters), infinite solutions exist. One possible array of intercoolers (or heaters) may be obtained by application of Specification 2 in which the L's and V's are obtained by material balances and the corresponding intercooler (or heater) duties by Equation (21).

The following procedure, called the Q-Method, for making enthalpy balances is directed toward finding the adiabatic solution if it exists. If this is impossible, intercoolers (or heaters) are employed as required to keep the flow rates throughout the column within specified limits. The limits for the liquid rates are denoted by $L_{min.}$ and $L_{max.}$. For any given trial, the flow rates are determined in the following manner.

Suppose for illustrative purposes that N, V_1, V_{N+1}, L_o and T_o have been specified and that a trial calculation has been carried out to give the enthalpies of all streams throughout the column. The variation of the liquid rates between successive trials is restricted as described for the vapor rates in Part I. When T_o is given, the enthalpy balances are initiated at the top and when T_{N+1} is specified, the balances are commenced at the bottom of the column. For an enthalpy balance around the top plate, Equation (22) reduces to

$$L_1 = \frac{V_1 [H_1 - H(y_1)_2] + L_o [H(x_o)_2 - h_o]}{[H(x_1)_2 - h_1]}$$

This value of L_1 is compared with $L_{1,1}$, the rate used in making the last trial calculation through the column. Suppose a "10 percent variation" per trial is permitted; that is if L_1 satisfies the inequality

$$L_{min.} < \frac{L_{1,1}}{1+p} < L_1 < (1+p)\, L_{1,1} < L_{max.}$$

(where p = 0.1 for the case under consideration), it is used in making the next trial through the column. The corresponding vapor rate to be employed for the next trial is calculated by material balance, Equation (23). If the value of L_1 computed by use of Equation (22) is less than $L_{1,1}/(1+p)$ and greater than L_{min}, then the value of L_1 to be employed for the next calculation through the column is taken equal to $L_{1,1}/(1+p)$. In order to keep the column in enthalpy balance at this liquid rate, an intercooler (or heater) is used on plate 1. The duty of the intercooler is calculated by an enthalpy balance as follows:

$$Q_{c1} = \left(\frac{L_{1,1}}{1+p}\right) [H(x_1)_2 - h_1] - V_1 [H_1 - H(y_1)_2] - L_o [H(x_o)_2 - h_o] \qquad (24)$$

For the case where $L_1 \leqq (1+p)\, L_{1,1}$ and $(1+p)\, L_{1,1}$ is equal to or less than $L_{max.}$, the calculational procedure is analogous to that described above. If either $L_1 \leqq L_{1,1}/(1+p) \leqq L_{min.}$ or $L_1 \geqq (1+p)\, L_{1,1} \geqq L_{max.}$, L_1 is taken equal to either $L_{min.}$ or $L_{max.}$, respectively, and the corresponding intercooler (or heater) duty is computed as indicated by Equation (24), where $L_{1,1}/(1+p)$ is replaced by either $L_{min.}$ or $L_{max.}$. The value of Q_{c1} is included in the enthalpy balance for the calculation of L_2. For adiabatic operation of plate 2

$$L_2 = \frac{V_1 [H_1 - H(y_1)_3] + L_o [H(x_o)_3 - h_o] + Q_{c1}}{[H(x_2)_3 - h_2]} \qquad (25)$$

If this value of L_2 corresponding to $Q_{c2} = 0$ lies within the prescribed limits, it is used in the next trial calculation through the column. If not, the appropriate limit is used and the corresponding value of Q_{c2} is computed in a manner analogous to that described for Q_{c1}. This procedure is continued throughout the column until L_{N-1} and $Q_{c,N-1}$ have been determined. Then the enthalpy of the rich gas is computed by the overall enthalpy balance,

$$H_{N+1} = \frac{V_1 H_1 + L_N h_N + \sum_{j=1}^{N-1} Q_{cj} - L_o h_o}{V_{N+1}} \qquad (26)$$

Alternately the temperature of the rich gas may be specified and the required intercooler (or heater) duty for Plate N may be calculated.

After each trial calculation through the column, the entire procedure is repeated and if adiabatic operation of each and every plate is possible, it is selected. If not, the required intercoolers (or heaters) are employed. For all problems known to have an adiabatic solution, the procedure just described converged to the same solution when the enthalpies were calculated by the constant-composition method. When the enthalpies were calculated by the conventional method of Part I and used in

the appropriate equations for the Q-method, convergence was obtained for all problems, but the solutions obtained were not always adiabatic.

Many problems for which adiabatic solutions were obtained by use of the constant-composition method did not appear to have adiabatic solutions when enthalpies were calculated by the conventional method. It should also be remarked that only minor modifications of the Q-method are required to permit the specification of an intercooler (or heater) duty for any given plate.

Equations (22) through (23) imply that V_{N+1} enters the column as a vapor either at its dew point at the column pressure or at some higher temperature and that L_o enters either at its bubble point at the column pressure or at some lower temperature. If either of these streams is a two-phase mixture, it may be handled in the same manner as shown in Part I for a partially vaporized feed.

4. Other Specifications. As indicated by Equation (12) and in a manner analogous to that shown in Part II, specifications other than V_1 may be made. The rate of convergence for each of these specifications is being investigated.

CALCULATION OF DEW POINTS AND BUBBLE POINTS

For the general case where single-phase components are present in both the liquid and vapor phases, dew points and bubble points are calculated by use of Equations (27) and (28), respectively. The values of the y_{ji}'s and x_{ji}'s needed to make the calculations are computed as described previously by use of Equations (13) through (16). The dew point calculation consists of finding the positive value of T_j such that $F(T_j) = 0$, where

$$F(T_j) = \sum_{i \neq 1, c} \frac{y_{ji}}{K_{ji}} - (1 - x_{j,c}) \qquad (27)$$

Similarly, the temperature of the bubble point is that positive value of T_j which gives $f(T_j) = 0$, where

$$f(T_j) = \sum_{i \neq 1, c} K_{ji} x_{ji} - (1 - y_{j,1}) \qquad (28)$$

It should be remarked that Equations (27) and (28) give the same temperature only after convergence for the given system has been obtained.

In order to obtain the effect of dew points and bubble points alone on the rate of convergence, a wide variety of examples were solved in which the vapor and liquid rates were held fixed throughout the column. These results suggested the following analysis. An examination of hydrocarbon systems shows that the rate of change of the equilibrium constant, K, with temperature increases as the molecular weight of the hydrocarbon is increased. For a very light component such as methane, this slope is of order zero over a fairly wide range of temperatures and pressures. On the other hand, for heavy components, the slope of K versus temperature is very large.

Consider first a system in which methane (or any component for which K is essentially independent of temperature) is the primary constituent of the gas phase. For any plate, the bubble point equation reduces approximately to $y = Kx \cong 1.0$. Since K for methane is almost independent of temperature, it follows that for small changes in composition of the liquid, large changes in temperature are required to satisfy the bubble point equation. As discussed in the next section, the Θ-method sometimes gives an over-correction for such systems.

Consider next the case where the liquid phase consists almost entirely of a very heavy component (or any component having a very large rate of change of K with temperature) and the corrected temperature is to be calculated by use of dew points. The dew point equation

TABLE 2—Statement of Examples

Component	Example 1		Example 2		Example 3, 12		Example 4		Example 5		Example 6		Example 7		Example 8		Example 9		Example 10		Example 11		Example 13		Example 14, 15, 16	
	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o	v_{N+1}	l_o
Single-Phase Light	..	..	..	..	..	..	....	..	....	..	..	..	....	..	....	..	..	..	....	..	70	..	....	..	..	..
CH_4	70	..	70	..	0	..	25	..	50	..	60	..	70	..	75	..	80	..	85	..	..	..	70	..	70	..
C_2H_6	15	..	15	..	70	..	52.5	..	35	..	28	..	21	..	17.5	..	14	..	10.5	..	15	..	15	..	15	..
C_3H_8	10	..	10	..	15	..	11.25	..	7.5	..	6	..	4.5	..	3.75	..	3	..	2.25	..	10	..	10	..	10	..
nC_4	4	..	4	..	10	..	7.5	..	5	..	4	..	3	..	2.5	..	2	..	1.5	..	4	..	4	..	4	..
nC_5	1	..	1	..	5	..	3.75	..	2.5	..	2	..	1.5	..	1.25	..	1	..	0.75	..	1	..	1.1	..	1	..
nC_6	..	..	..	..	..	20	....	20	....	20	..	20	....	20	....	60	..	..	....	..	..	..	....	..	..	..
nC_8	..	..	..	..	..	..	....	..	....	..	..	..	....	..	....	..	..	40	....	70	..	..	....	..	..	20
500	..	15	..	..	..	..	....	..	....	..	..	..	....	..	....	..	..	..	....	..	..	15	....	20	..	..
Single-Phase Heavy	..	..	..	20	..	..	....	..	....	..	..	..	....	..	....	..	..	..	....	..	..	..	....	..	..	..

TABLE 3—Specifications for Example 1 Through 16

Example	Specifications
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	Column pressure for Examples 1, 2 and 11, is 400 psia and for Examples 3 through 10 is 300 psia. For Examples 1 through 8 and 11, V_1 = 85 and for Examples 9 and 10, V_1 = 90. For Examples 1 through 11, N = 8. Intercoolers (or heaters) are employed for all examples such that an equal number of moles are absorbed per plate; that is $V_j = V_1 + (j-1)\left(\frac{V_{N+1} - V_1}{N}\right)$ and $L_j = L_o + j\left(\frac{V_{N+1} - V_1}{N}\right)$. Equilibrium and enthalpy data shown in Part II and in Table 4 (herein) were used.
12, 13	Column pressure = 300 psia, V_1 = 85 and N = 8. Intercoolers (or heaters) available to operate the column at the liquid and vapor rates obtained by the material-balance equations.
14	Column pressure = 300 psia, V_1 = 85 and N = 8. Lean oil enters at 90° F. Intercoolers (or heaters) are available to give a set vapor rates bounded as follows: $88 \leq V_l \leq 93$, $(1 < l < N + 1)$. Convention-method used in enthalpy balances.
15	Column pressure = 300 psia, V_1 = 85 and N = 8. Lean oil enters at 90° F. Intercoolers (or heaters) are available to give a set of vapor rates bounded as follows: $88 \leq V_j \leq 93$, $(1 < j < N + 1)$. Constant-composition method used in enthalpy balances.
16	Column pressure = 300 psia, V_1 = 85 and N = 8. Lean Oil enters at 90°F Adiabatic solution desired. Constant-composition method used in enthalpy balances.

reduces approximately to $y/K = x$ (for the heavy component) $\cong 1.0$. Thus for large changes in y for the heavy component, small changes in T are required to satisfy the dew point equation. Use of dew points for such systems gives a slow rate of convergence and this procedure for the calculation of the temperature is not in general recommended. This undesirable property of dew points was illustrated by solving Example 1 of Table 2 by use of a combination of the Θ-method and dew points.

After 124 trials the problem was still converging slowly. For systems consisting of relatively light components, very satisfactory results were obtained by use of the Θ-method and dew points. Similarily, when the lean oil is treated as a single-phase liquid component, rapid convergence is given by dew points. Example 2 was solved by use of the Θ-method and dew points. Convergence to a value of V_1 correct to five digits and to a tempeature profile to within 0.1° F was obtained in 13 trials.

Illustrative Examples

Since all problems could not be solved rapidly by use of dew points, efforts were directed toward reducing the strong convergence tendencies of bubble points in order to make them suitable for the solution of all absorber problems. For systems containing up to about 50 or 60 percent light components (which appear in both the vapor and liquid phases) the use of the combination of the Θ-method and bubble points gives very satisfactory results. This is illustrated by Examples 3 through 11, Tables 2, 3, 4, and 5.

In all of the examples shown, temperature profiles for successive trials were averaged plate by plate. That is, for all trials after the second one, the calculated profile for a given trial was averaged with the one used to make the given trial calculation. Above about 50 or 60 percent lights, the combination of the Θ-method and bubble points (with averaging) tends to give overcorrections which are characterized by the calculation of temperature profiles and values for V_1 which are alternately too large and too small. The precise percentage of lights at which this overcorrection becomes pronounced depends of course on the amount and molecular weight of the lean oil, as shown in Tables 2 and 5.

The range of operation for the combination of the Θ-method and bubble points may be extended by placing more severe restrictions (than that represented by averaging) on the variation of the temperature profiles for successive trials. For example, only one-fourth of the calculated correction may be used,

$$T_{\substack{\text{new assumed}\\ \text{value}}} - T_{\substack{\text{last assumed}\\ \text{value}}} = \frac{T_{\substack{\text{calculated}\\ \text{value}}} - T_{\substack{\text{last assumed}\\ \text{value}}}}{4}$$

In the treatment of absorbers, no restrictions other than averaging were used. For those examples containing a large percentage of lights, the overcorrection given by the Θ-method was eliminated by taking $\Theta = 1.0$ for each trial. This procedure is referred to as direct itera-

TABLE 4—Equilibrium data and Enthalpy data

Component	$a_1 \times 10$	$a_2 \times 10^3$	$a_3 \times 10^6$	$a_4 \times 10^9$
CH_4	−3.2551482	2.3553786	−3.1371170	1.3397973
C_2H_6	−2.7947232	1.4124232	−1.4582948	0.50974162
C_3H_8	−2.7980091	1.1811943	−1.0935041	0.35180421
nC_4	−2.3203344	0.83753226	−0.61774360	0.15243376
nC_5	0.37103008	−0.36257004	0.09113800	−0.54441110
500	1.9642644	−0.81121972	1.0586630	−0.39478662

$(K_l/T)^{1/2} = a_{1l} + a_{2l}\,T + a_{3l}\,T^2 + a_{4l}\,T^3$, (T in °R)
For the 500—Component:
$H^{1/2} = 138.49658 + 0.14978171\,T + 1.8641269 \times 10^{-4}\,T^2$, (T in °R)
$h^{1/2} = 1.9205300 + 0.30179232\,T - 2.2183809 \times 10^{-4}\,T^2$, (T in °R)
Equilibrium data at 400 psia was taken from Reference (24).
Enthalpy data was taken from Reference (10).

TABLE 5—Use Θ-method for absorber problems with a small percentage of lights and direct iteration for problems with a large percentage of light components

Example	% CH_4 in V_{N+1}	BUBBLE POINTS (WITH AVERAGING) Θ-Method No. of Trials $\left\lvert\frac{\Delta V_1}{V_1}\right\rvert \leq 0.01$	Θ-Method No. of Trials $\left\lvert\frac{\Delta V_1}{V_1}\right\rvert \leq 0.001$	Direct Iteration (Θ = 1) No. of Trials $\left\lvert\frac{\Delta V_1}{V_1}\right\rvert \leq 0.01$	Direct Iteration (Θ = 1) No. of Trials $\left\lvert\frac{\Delta V_1}{V_1}\right\rvert \leq 0.001$
3	0	6	12	8	12
4	25	7	11	10	20
5	50	5	11	9	14
6	60	3	9	5	13
7	70	*	*	6	9
8	75	*	*	7	20
9	80	**	**	6	13
10	85	**	**	10	34
11	0	3	7	12	37

* Temperature profiles and V_1 bounced high and low with amplitudes which decreased with trial numbers, but had not converged to the specified accuracy at the end of 20 trials.
** Temperature profiles and V_1 bounced high and low with amplitudes which increased with trial numbers.

TABLE 6—Solution of Example 7 By Use of Direct Iteration and Bubble Points

Plate No.	TEMPERATURE PROFILES (°F) TRIAL NUMBER							FINAL FLOW RATES (TRIAL 19)	
	Initial Profile	1	2	11	12	19	28*	Component	v_i
1	240	121.1	112.2	114.4	114.6	114.7	114.7	CH_4	68.04
2	230	40.0	45.9	66.5	66.8	66.5	66.5	C_2H_6	12.2
3	220	20.0	40.5	53.6	53.5	52.5	52.5	C_3H_8	2.68
4	210	40.0	40.0	49.0	48.7	47.8	47.9	nC_4	5.9×10^{-4}
5	200	40.0	40.0	48.3	48.0	47.4	47.4	nC_5	3.64×10^{-9}
6	190	40.0	40.0	50.9	50.6	50.2	50.2	nC_6	2.06
7	180	40.0	42.7	58.8	58.6	58.2	58.2	....	.....
8	170	40.0	61.1	73.5	73.3	73.1	73.1	....	.....
V_1 (Calculated)	...	104.1	83.3	85.047	85.045	84.998	85.000006	....	.....

* Profiles between successive trials agreed to within 8 digits.

TABLE 7—Solutions for Examples 12 and 13 (Liquid and vapor rates determined by material balances)

SOLUTION OF EXAMPLE 12 (Θ-Method and Bubble Points)					SOLUTION OF EXAMPLE 13 (Direct Iteration, Θ = 1, and Bubble Points)				
Plate No.	Final* Profile, °F (Trial 11)	V_j	Component	v_i	Plate No.	Final Profile, °F (Trial 14)	V_j	Component	v_i
1	221.39	85.00	C_2H_6	61.62	1	201.6**	85.00	CH_4	67.92
2	190.37	86.31	C_3H_8	10.16	2	199.5	88.01	C_2H_6	12.23
3	171.93	85.79	nC_4	2.50	3	171.9	88.15	C_3H_8	4.62
4	159.10	86.07	nC_5	0.32×10^{-1}	4	149.3	88.61	nC_4	0.23
5	150.49	87.06	nC_6	10.66	5	131.3	89.21	nC_5	3.40×10^{-4}
6	145.57	88.7	.....	.....	6	117.5	89.95	500	0.61×10^{-1}
7	144.26	91.17	.....	.....	7	108.4	90.87	.....	.....
8	145.84	94.68	.....	.....	8	70.7	92.04	.....	.....
V_1 (Calculated)	85.00036				V_1 (Calculated)	85.084			
Θ	1.0000212								

* Profiles between successive trials agreed to within 8 digits.
** Profiles between successive trials agreed to within 0.2° F.

tion. Thus when bubble points are employed, systems which contain a large percentage of light components are so strongly convergent that the corrections of the Θ-method constitute an overcorrection. However, it is to be observed that direct iteration may lead to a slow rate of convergence for some of those examples for which rapid convergence is obtained by the Θ-method, as illustrated in Table 5. Thus, it is suggested that the combination of direct iteration and buble points (with averaging) be used only after it has been found that the combination of the Θ-method and bubble points (with averaging or quartering) leads to bouncing as a result of an overcorrection. An example of this type is Example 7; see Tables 2, 3, 4, 5, and 6. Treatment of a light component as a single-phase component reduces the convergence tendency exhibited by the component when it is considered to be distributed between two phases. This is illustrated by Example 11, Tables 2, 3, 4, and 5.

In order to demonstrate the use of the second type of specification, Examples 12 and 13 were solved to give the solutions shown in Table 7. In the solution of these examples, no restrictions were placed on the calculated values of V_j. However, it was found that without restrictions, solutions corresponding to an excessive amount of internal reflux were obtained for some problems. This is easily prevented by using only those values of V_j and L_j [computed by Equations (19) and (20)] which lie within certain specified limits for making the next trial calculation through the column. If a calculated value lies outside the given limits, the closest limit to the calculated value is employed in the next trial calculation.

In order to demonstrate the difference between the conventional and the constant-composition methods for the calculation of enthalpies, the solutions for Examples 14 and 15 are shown in Tables 8 and 9. These problems were solved under the same restrictions for the vapor rates. In Example 14, the enthalpies were calculated by the conventional method and in Example 15, by the constant-composition method. Thus it is seen that the use of enthalpies calculated by the conventional method, tends to drive the problem away from an adiabatic solution; whereas, the use of enthalpies computed by the constant-composition method tends to give either the adiabatic solution or the minimum number of intercoolers (or heaters).

When the limits of the vapor rates were further ex-

tended and when the enthalpies were calculated by the conventional method, the problem diverged further away from the adiabatic solution. However, when the enthalpies were computed by the constant-composition method, the adiabatic solution shown as Example 16, Table 10, was obtained.

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SYMBOLS USED

(See also Parts 1 and 3)

	An enthalpy function; defined after Equation (22).
L_o	Total molal rate of flow of lean oil.
L_N	Total molal rate of flow of rich oil
V_{N+1}	Total molal rate of flow of rich gas
V_1	Total molal rate of flow of lean gas.

Greek Letters

σ_j	A multiplier; defined by Equation (3 2).
τ_j	A multiplier; defined by Equation (3 3).
ϕ, Φ	A product and a sum of products of stripping factors, respectively; defined below Equation (6).
ω, Ω	A product and a sum of products of absorption factors, respectively; defined below Equation (2).

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(See also Part 1)

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EQUATIONS DEVELOPED

Equality of Flow Rates Calculated by Use of Equations (1) and (5). First, for any preassigned set of L/V's and K's, it will be shown that the expressions for l_{N1}/v_{11}, Equations (4) and (6) are equivalent. This will be shown by demonstrating that Equation (4) may be obtained from Equation (6). Division of both the numerator and denominator of Equation (6) by ϕ_1 gives an expression containing the following ratios.

$$\frac{1}{\Phi_1} = \frac{1}{S_{11} \cdots S_{N1}} = A_{11} \cdots A_{N1} = \omega_1$$

$$\frac{\Phi_1}{\phi_1} = A_{11} \cdots A_{N1} + A_{21} \cdots A_{N1} + \cdots + A_{N1} = \Omega_1 + \omega_1 - 1$$

When these results are substituted into the expression obtained by division, Equation (4) is obtained.

It will now be shown that for the case where a component enters in the stream V_{N+1} alone, the same set of values for the individual flow rates are obtained regardless of whether calculations are made from the top of the column down or from the bottom to the top. In particular let attention be focused on a plate located n plates from the top of a column containing a total of N plates. Successive application of Equation (5) up to plate n yields

$$\frac{v_{n1}}{l_{N1}} = S_{n1} \cdots S_{N1} + \left(S_{n1} + S_{n1}S_{n+1,1} + \cdots + S_{n1} \cdots S_{N-1,1}\right)\left(1 - \frac{v_{N+1,1}}{l_{N1}}\right) \quad (29)$$

since $v_{n1} = S_{n1}l_{n1}$. Similarly, successive application of Equation (1) from the top of the column down to plate n gives

$$\frac{v_{n1}}{v_{11}} = A_{n-1,1} \cdots A_{11} + (1 + A_{n-1,1} + A_{n-1,1} \cdots A_{21}) \quad (30)$$

That these two values of v_{n1} are equal is proven by showing that Equation (30) may be derived from Equation (29), which is carried out in the following manner. Since $l_{o1} = 0$, an overall material balance reduces to

$$1 - \frac{v_{N+1,1}}{l_{N1}} = -\frac{v_{11}}{l_{N1}}$$

multiplication of both sides of Equation (29) by l_{N1}/v_{11} yields

$$\frac{v_{n1}}{v_{11}} = \left(S_{n1} \cdots S_{N1}\right)\left(\frac{l_{N1}}{v_{11}}\right) - \left(S_{n1} + S_{n1}S_{n+1,1} + \cdots + S_{n1} \cdots S_{N-1,1}\right) \quad (31)$$

since the expressions for l_{N1}/v_{11} have been shown to be equivalent, either the one given by Equation (4) or Equation (6) may be substituted in Equation (31). For the case where $l_{o1} = 0$, the numerator of the right hand side of Equation (4) reduces

TABLE 8—Solution of Example 14 by Use of the Q-Method and the Conventional Formulas for Enthalpies

	TEMPERATURES, VAPOR RATES AND INTERCOOLER (or Heater) DUTIES						FINAL FLOW RATES (Trial No. 28)		
	Temp. °F Trial No.			Vapor Rates Trial No.		Q_{Ci} Trial No.			
Plate No.	Initial Profile	7	28	Initial Profile	28	28	Component	v_1	l_N
1	240	147.7	146.7	85.0	85	-1.4×10^5	CH_4	67.929	2.071
2	230	44.8	63.2	86.8	88	1.9×10^5	C_2H_6	12.132	2.868
3	220	40.0	118.9	88.7	93	3.0×10^4	C_3H_8	42.429×10^{-1}	5.757
4	210	134.8	195.6	90.6	93	-2.5×10^5	nC_4	13.815×10^{-2}	3.862
5	200	69.2	93.6	92.5	88	2.8×10^5	nC_5	19.887×10^{-6}	99.998×10^{-3}
6	190	133.3	191.9	94.3	93	-3.0×10^5	nC_8	56.226×10^{-2}	19.438
7	180	76.6	70.0	96.2	88	1.8×10^5			
8	170	74.3	68.4	98.1	93	0.0			
V_1 (Calculated)		84.49	85.004						

TABLE 9—Solution of Example 15 By Use of The Q-Method and the Constant-Composition Formulas for Enthalpies

	TEMPERATURES, VAPOR RATES AND INTERCOOLER (or Heater) DUTIES						FINAL FLOW RATES (Trial No. 21)		
	Temp. °F Trial No.			Vapor Rates Trial No.		Q_{c_i} Trial No.			
Plate No.	Initial Profile	7	21*	Initial Profile	21	21	Component	v_1	l_N
1	240	104.8	107.7	85.0	85.0	0.0	CH_4	67.945	2.054
2	230	103.0	111.6	86.8	89.8	0.0	C_2H_6	12.275	2.724
3	220	98.1	112.8	88.7	90.5	0.0	C_3H_8	45.174×10^{-1}	5.482
4	210	93.9	112.6	90.6	90.7	0.0	nC_4	87.576×10^{-3}	3.912
5	200	92.5	110.9	92.5	91.0	0.0	nC_5	71.500×10^{-7}	1.000
6	190	92.7	106.8	94.3	91.2	0.0	nC_6	17.514×10^{-2}	19.824
7	180	89.9	98.0	96.2	91.7	-3.7×10^3			
8	170	72.4	73.7	98.1	93.0	0.0			
V_1 (Calculated)		84.40	85.0013						

* Profiles between successive trials agreed to within 4 digits.

TABLE 10—Adiabatic Solution of Example 16 Obtained by the Use of the Q-Method and the Constant-Composition Formulas for Enthalpies

	TEMPERATURES, AND VAPOR RATES					FINAL FLOW RATES (Trial No. 25)		
	Temp. °F Trial No.			Vapor Rates Trial No.				
Plate No.	Initial Profile	7	25*	Initial Profile	25	Component	v_1	l_N
1	240	105.2	107.6	85.0	85.0	CH_4	67.950	2.049
2	230	102.7	111.4	86.8	89.8	C_2H_6	12.282	2.717
3	220	101.2	112.4	88.7	90.5	C_3H_8	45.084×10^{-1}	5.491
4	210	99.8	112.1	90.6	90.7	nC_4	83.566×10^{-3}	3.916
5	200	100.2	110.2	92.5	90.9	nC_5	66.002×10^{-5}	1.000
6	190	101.4	105.8	94.3	91.2	nC_6	17.451×10^{-2}	19.825
7	180	97.1	96.4	96.2	91.8			
8	170	74.3	74.3	98.1	93.1			
V_1 (Calculated)		84.42	84.9996					

* Profiles between successive trials agreed to within 4 digits.

to $(\Omega_i + \omega_i - 1)$. When this expression is substituted into Equation (31), among other terms the following products are obtained.

$$\begin{aligned}(S_{ni} \cdots S_{Ni})\Omega_i &= (S_{ni} \cdots S'_{Ni})(1 + A_{Ni} + A_{Ni}A_{N-1,i} + \cdots \\ &\quad + A_{Ni} \cdots A_{ni} + A_{Ni} \cdots A_{ni}A_{n-1,i} + \cdots \\ &\quad + A_{Ni} \cdots A_{ni}A_{n-1,i} \cdots A_{2i}) \\ &= S_{ni} \cdots S_{Ni} + S_{ni} \cdots S_{N-1,i} + \cdots \\ &\quad + 1 + A_{n-1,i} + \cdots + A_{n-1,i} \cdots A_{2i}\end{aligned}$$

and

$$\begin{aligned}(S_{ni} \cdots S_{Ni})\,\omega_i &= (S_{ni} \cdots S_{Ni})\,(A_{Ni} \cdots A_{ni}A_{n-1,i} \cdots A_{1i}) \\ &= A_{n-1,i} \cdots A_{1i}\end{aligned}$$

After these values have been substituted and like terms have been collected, the desired result, Equation (30), is obtained. For the case where a component enters in both L_o and V_{N+1}, the corresponding proof is carried out in an analogous manner.

Development of Equations (13) Through (16). Consider an absorber for which V_j and L_j are fixed for each plate by use of appropriate intercoolers (or interheaters). Suppose a calculation has been carried out as described previously to give $(v_{1i})_{ca}$ and $(v_{ji}/v_{1i})_{ca}$ for all j. Further, suppose there exists a set of corrected values for v_{1i} and l_{Ni} which are in component material balance and whose sums for all components except 1 and c are equal to the specified values of $(V_1 - v_{1,1})$ and $(L_N - l_{N,c})$, respectively. Now, the problem arises as to the formulas to be employed for the calculation of the vapor and liquid compositions. Certainly, on any plate j, the contribution of the distributed components to the total rate of flow involves the term

$$\sum_{i \neq 1,c} \left(\frac{v_{ji}}{v_{1i}}\right)_{ca} (v_{1i})_{co}$$

It might appear that V_j is equal to the value of this sum plus $v_{j,1}$. However, this equality was not listed as one of the conditions to be fulfilled by the corrected value of v_{1i}. On the other hand, if the value of the above sum plus $v_{j,1}$ is not equal to v_j, the error lies not in $v_{j,1}$ (since it is known for each plate), but in the value of the sum for the distributed components. Then, let σ_j be defined by

$$(v_{ji})_{co} = \sigma_j \left(\frac{v_{ji}}{v_{1i}}\right)_{ca} (v_{1i})_{co}, i \neq 1, c, 1 \leqq j \leqq N \quad (32)$$

Similarily, let τ_j be defined by

$$(l_{ji})_{co} = \tau_j \left(\frac{l_{ji}}{l_{Ni}}\right)_{ca} (l_{Ni})_{co}, i \neq 1, c, 1 \leqq j \leqq N \quad (33)$$

For $j = 0$ and $j = N + 1$, more general definitions are permitted for σ and τ in that only the ratio of $(\tau_{N+1,i}/\sigma_{oi})$ is taken to be independent of i. That is

$$(v_{N+1,i})_{co} = \sigma_{N+1,i} \left(\frac{v_{N+1,i}}{v_{1i}}\right)_{ca} (v_{1i})_{co}, i \neq 1, c \quad (34)$$

$$(l_{oi})_{co} = \tau_{oi}\left(\frac{l_{oi}}{l_{Ni}}\right)_{ca}(l_{Ni})_{co}, i \neq 1, c \quad (35)$$

Furthermore, it is given that $(v_{i1})_{co}$ and $(l_{Ni})_{co}$ are in material balance, (Equation (9)), and that these corrected values satisfy the following conditions

$$\sum_{i \neq 1, c}(v_{i1})_{co} = V_1 - v_{1,1} \quad (36)$$

$$\sum_{i \neq 1, c}(l_{Ni})_{co} = L_N - l_{N,c} \quad (37)$$

On the basis of the given postulates, it is to be shown that Equations (13) through (18) follow.

Expressions for V_j and L_j are obtained by summation of both sides of Equations (32) and (33) overall components except 1 and c followed by the addition of $v_{j,1}$ and l_{jc} to each side of the respective equations to give

$$V_j = \sum_{i \neq 1, c}\sigma_j\left(\frac{v_{ji}}{v_{i1}}\right)_{ca}(v_{i1})_{co} + v_{j,1},\ 1 \leqq j \leqq N \quad (38)$$

$$L_j = \sum_{i \neq 1, c}\tau_j\left(\frac{l_{ji}}{l_{Ni}}\right)_{ca}(l_{Ni})_{co} + l_{j,c},\ 1 \leqq j \leqq N \quad (39)$$

Since l_{o1} and $v_{N+1,1}$ are known feed rates, the corrected and calculated values are equal. Thus, Equations (34) and (35) reduce to

$$(v_{i1})_{co} = \left(\frac{1}{\sigma_{N+1,i}}\right)(v_{i1})_{ca}$$

$$(l_{Ni})_{co} = \left(\frac{1}{\tau_{oi}}\right)(l_{Ni})_{ca}$$

By division of the corresponding members of the second of these equations by those of the first, the following result is obtained.

$$\left(\frac{l_{Ni}}{v_{i1}}\right)_{co} = \left(\frac{\sigma_{N+1,i}}{\tau_{o,i}}\right)\left(\frac{l_{Ni}}{v_{i1}}\right)_{ca} = \theta_o\left(\frac{l_{Ni}}{v_{i1}}\right)_{ca} \quad (40)$$

where θ_o is independent of i by the definition of the ratio of τ_{oi} to $\sigma_{N+1,i}$.

When Equation (40) is combined with Equation (9), the desired formula for $(v_{i1})_{co}$, (Equation (17)) is obtained. The sum of the corrected v_{i1}'s is given by Equation (36) which leads to the expression for $g_o(\Theta_o)$, Equation (18). The quantity Θ_o, needed for the computation of the corrected v_{i1}'s is the positive root of $g_o(\Theta_o) = 0$.

The expressions for the calculation of the mole fractions, Equations (13) through (16), are developed in the following manner. By use of the conventional definition of the mole fraction and Equations (32) and (38) it follows:

$$y_{j1} = \frac{\sigma_j\left(\frac{v_{j1}}{v_{i1}}\right)_{ca}(v_{i1})_{co}}{\sum_{i \neq 1, c}\sigma_j\left(\frac{v_{j1}}{v_{i1}}\right)_{ca}(v_{i1})_{co} + v_{j,1}},\ 1 \neq 1, c \quad (41)$$

After Θ_o has been determined, the values for σ_j may be computed by use of the following formula which is obtained by a rearrangement of Equation (38)

$$\sigma_j = \frac{V_j - v_{j,1}}{\sum_{1 \neq 1, c}\left(\frac{v_{j1}}{v_{i1}}\right)_{ca}(v_{i1})_{co}} \quad (42)$$

When this expression for σ_j is substituted into Equation (41), the result obtained is Equation (13). The expressions given by Equations (14) through (16) are developed in an analogous manner.

Key Words for Indexing

Absorbers
Absorption
Boiling Points
Compositions
Computations
Computers
Enthalpy
Separations

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Don't Be Confused By Rotary Pump Performance Curves

Engineers often throw up their hands when screw or gear pumps operate at viscosities other than those shown on the curves. Here's how to find new conditions easily

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Specify performance curves properly. A performance curve properly specified and prepared is one of the most important tools a pump engineer can have. This applies for both evaluating and operating pumps. The primary objective of this article will be to show ways of specifying and extrapolating rotary pump performance curves.

The number of centrifugal pumps in service far outnumbers any other type of pump. As a result, performance curve requirements on all pumps are patterned after centrifugal pumps.

Centrifugal vs Rotary. There is a considerable difference between the performance curves of a centrifugal and a rotary pump. Figure 1 illustrates this clearly.

A rotary pump is generally used for different pumping applications than a centrifugal pump. It usually handles viscous liquids or liquids having a wide range of viscosities. Also it is ideal for high head low capacity applications.

Rotary pump specifications should request a curve as follows:

"A curve should be furnished indicating capacity, brake horsepower, and mechanical efficiency plotted against discharge pressure, for both maximum and minimum viscosities specified. Curves of capacity and brake horsepower to originate at the abscissa." (See Figure 2).

With a curve such as this the engineer is well equipped and self sufficient in making extrapolations with reasonable accuracy.

Rotary Pump Rules. There are a few rules that generally apply to rotary pumps and perhaps should be mentioned at this point.

- Slip capacity is a function of viscosity and discharge pressure only and not affected by speed. Slip capacity is defined as the amount of fluid leaking from the pump discharge to the pump suction through the internal pump clearances. Assuming no change in clearances, this leakage will only be affected, for all practical purposes, by the discharge pressure and viscosity of the fluid being pumped.
- Capacity is proportional to speed at 0 psig discharge pressure.
- Slip capacity is a logarithmic function of viscosity at constant discharge pressure.
- Friction horsepower is a logarithmic function of viscosity at constant speed.

Example. To illustrate use of the above rules:

"A pump is required to deliver 53 gpm of fluid at a discharge pressure of 1,000 psig. The pumping temperatures will range from 90 to 230° F with corresponding viscosities of 10,000 to 150 SSU."

In order to meet these conditions a screw pump operating at 1,150 rpm and requiring a 75 horsepower driver would be used. The performance curve would be as shown in Figure 2.

The above data may be required for preliminary design estimates. Let's assume that after the project engineer receives above data, he determines that the range of pumping temperatures specified is too great and a more realistic figure would be 110 to 150° F with corresponding viscosities of 4,000 to 950 SSU. Usually under these circumstances the project engineer will refer the changed viscosities to the pump manufacturer asking for additional data. Sometimes this happens three and four times.

The project engineer can determine the changed conditions of capacity, brake horsepower, and mechanical

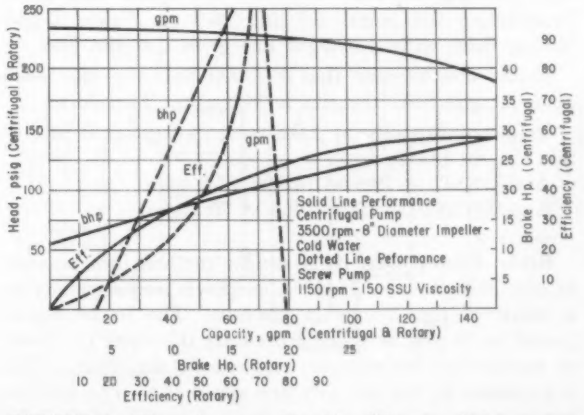


FIGURE 1—There is a considerable difference between centrifugal and rotary pump curves.

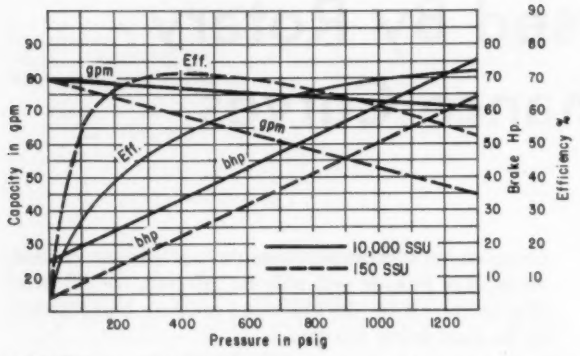


FIGURE 2—Performance curves of a rotary screw pump showing characteristics at two viscosities.

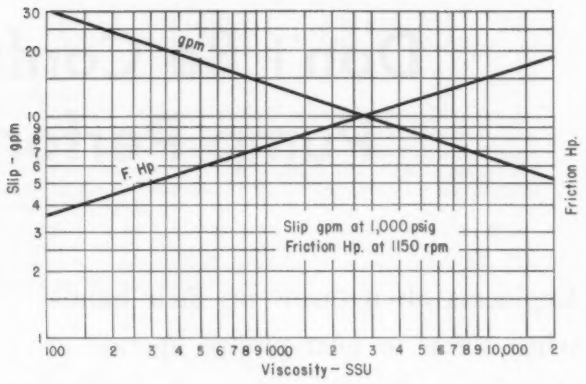


FIGURE 3—The slip capacity at other viscosities can be found by drawing these curves.

efficiency for the new viscosities himself by referring to the previously listed rules and performance curve Figure No. 2.

This is done as follows:

Slip. The slope of the gpm lines represents the internal slippage in the pump. At 0 psig discharge the slip gpm is zero. In a well designed pump, where the deflection of the internal parts is insignificant, the slip gpm caused by a change in discharge pressure is a linear function and a curve of gpm slip versus psig discharge, plotted on coordinate graph paper, would result in a straight line. This is true only if the viscosity is held constant.

If the viscosity changes, which is the problem here, the situation is entirely different. It can be stated that a decrease in viscosity results in an increase in slip and visa versa, assuming a constant discharge pressure.

To determine the slip at a viscosity other than shown on performance curve Figure 2, establish the slip at the desired discharge pressure and both viscosities. From Figure 2 at 1,000 psig the delivered capacity is 73 gpm at 10,000 SSU and 53 gpm at 150 SSU. Since the delivered capacity at 0 psig is 79.5 gpm, the slip capacity at 10,000 SSU is 79.5 — 73 equals 6.5 gpm. At 150 SSU the slip capacity is 79.5 — 53 equals 26.5 gpm. Establishing the points 6.5 and 26.5 on Figure 3 and joining them with a straight line gives the gpm line.

It can now be seen that at 4,000 SSU the slip is 8.8 gpm. At 950 SSU the slip is 14.3 gpm. Therefore:

Delivered capacity at 1,000 psig = Cap. at 0 psig — Slip Cap. at 1,000 psig

At 950 SSU = 79.5 — 14.3 = 65.2 gpm

At 4,000 SSU = 79.5 — 8.8 = 70.7 gpm

Brake Horsepower. By a similar method it is possible to establish the new brake horsepower requirements as a result of the change in viscosity. The brake horsepower at 0 psig actually represents the total frictional or mechanical horsepower required by the pump. This is governed by the viscosity and speed only. The friction horsepower varies as a logarithmic function of the viscosity. Therefore, join the two points (4 and 15 bhp. From Figure 2, bhp at 0 psig for 150 SSU and 10,000 SSU), using log-log paper, with a straight line. From this line the friction horsepower at any other viscosity can be obtained (See Figure 3).

Brake horsepower is the sum of hydraulic horsepower and friction horsepower.

Hydraulic horsepower = (gpm) (psig)/1,714

(Note: gpm must be taken at 0 psig)

Therefore hydraulic horsepower = (79.5) (1,000)/ 1,714 = 46.4

Brake horsepower:

at 4,000 SSU = 46.4 + 11.2 = 57.6 bhp

at 950 SSU = 46.4 + 7.2 = 53.6 bph

Efficiency. Since the delivered capacity at 4,000 SSU and 1,000 psig is 70.7 gpm, and the bhp is 57.6, mechanical efficiency becomes:

$$\text{Eff.} = \text{Hydraulic hp} \div \text{bhp} \; \frac{(70.7)(1{,}000)}{1{,}714(57.6)} = 71.6\%$$

At 950 SSU and 1,000 psig, the capacity is 65.2 gpm and the brake horsepower is 53.6. Therefore the mechanical efficiency is:

$$\text{Eff.} = \frac{(65.2)\,(1{,}000)}{1{,}714\,(53.6)} = 71.0\%$$

Volumetric Efficiency, which so far has not been mentioned, is nothing more than the relationship between the true displacement, and the delivered capacity, or in other words is the measurement of internal slip losses.

In the cited example, true displacement at 1,150 rpm is 79.5 gpm and can be read from Figure 2. It is the delivered capacity at 0 psig.

The delivered capacity for 1,000 psig and 4,000 SSU is 70.7 gpm. Therefore the volumetric efficiency is:

70.7/79.5 = 88.8%

Key Words for Indexing

Capacity, Efficiency, Horsepower, Performance, Pumps

##

Bright Outlook for Acrylics

Lower cost processes and raw materials, new and improved products, coupled with broader markets point to added growth for these versatile petrochemicals

Joseph Gordon, Los Angeles

More and better petrochemical processes are providing the acrylic producers with the springboard for a new period of sustained growth. Twice before—in 1942-1945 and 1953-1959—growth was meteoric but each time the one-sided demand led eventually to a slowing down of the pace. But now with strong prospects of lower manufacturing costs and broader markets, producers confidently expect that future acrylics growth, though perhaps less spectacular, will have more stamina.

All three of the major acrylics—acrylonitrile, acrylates and methacrylates—are marked for expansion. Within this growth some important trends are evident, with more attention focussed on the following sectors: (1) Copolymers (2) New product development (3) Market development and (4) Acrolein and acrylic derivatives.

In acrylonitrile, the acrylic fibers now consume about ⅔ of its production. They will continue as the chief outlet, but their share most likely will diminish as other uses expand or develop in copolymer plastics and elastomers such as nitrile rubber and ABS plastics, as well as other uses including derivatives.

The acrylates, relatively new to large volume use, are booming the most in emulsions, particularly in latex paints which now account for about half its total output.

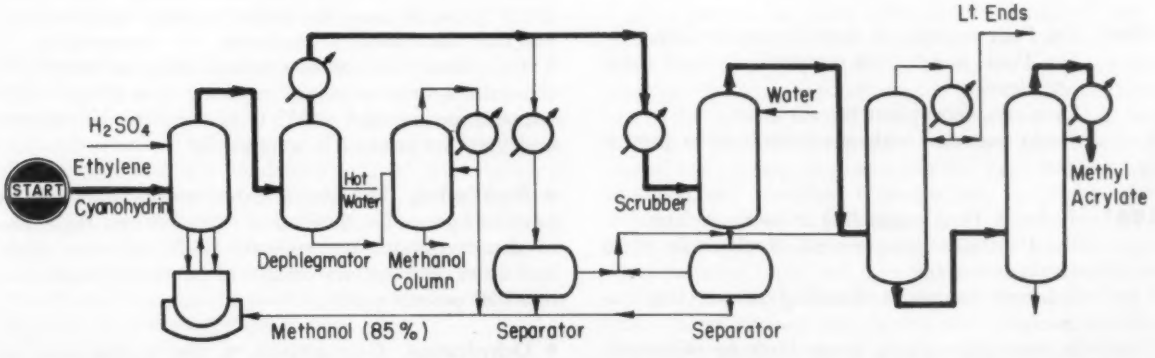


FIGURE 1—Methyl acrylate from ethylene cyanohydrin and methyl alcohol uses a scheme of hydrolysis-esterification reactions.

In this application alone, estimated annual use increased from about 5 million pounds in 1954 to over 30 million in 1960.[1]

Methacrylates, first acrylic in commercial use, are in the midst of a surge. Leading its uses is methyl methacrylate for plastic signs and glazing, but surface coating uses are mounting fast.

Acrolein, a fourth acrylic due to be heard from, is newly available from propylene oxidation, and precursor to glycerine in Shell's 35-million-pounds/year plant at Norco, La.

RECENT DEVELOPMENTS

One of the surest guides to producer interest is the scope of their expansion activity. Each of the major acrylics has recently completed or has underway an expansion program calling for some 50 percent increase in capacity in a two year period. In acrylonitrile and in acrylates this expansion came from 1958 to 1960; in methacrylates, the boost is now in progress and due for completion early in 1963.

In this five-year period, at least four new processes will be put to commercial use, and at least four new producers will have ventured into the major acrylics. Also, in moves toward product integration, Du Pont a leader in methacrylates and chief buyer of acrylonitrile, has gone into manufacture of the latter as well. American Cyanamid, a leader in acryonitrile, is now planning to go into methacrylates.

Some prominent events in this expansion activity have been:

1958—Acrylonitrile expansion by American Cyanamid and Union Carbide
Dow into acrylic fibers and styrene-methacrylate
Celanese into acrylate manufacture by Goodrich process

1959—American Cyanamid into acrylic fibers
Monsanto and Goodrich into ABS terpolymers
Shell completes acrolein from propylene plant

1960—Du Pont expands in methyl methacrylate
Du Pont builds first acrylonitrile unit from acetylene
Dow completes plant for acrylates
Sohio onstream with acrylonitrile from propylene

1961—Rohm & Haas expanding in methacrylates
Du Pont building second acrylonitrile plant (from propylene)
Celanese completes doubling of acrylate capacity
Methacrylate plants being built by American Cyanamid (from acetone cyanohydrin) and by Escambia Chemical (from isobutylene)

Judging by this expansion pace and interest it seems reasonable to expect at least one more producer of at least one acrylic to be in production by 1963. Among those with more than a casual interest in expansion are Monsanto Chemical, Dow Chemical, Eastman Chemical and a number of petroleum refiners. Producers and prospectives are motivated mainly by three desires: 1) Diversification 2) Securing captive production and 3) Upgrading of raw materials.

Coupled with, and a cause of, some of these expansions is a growing shift toward olefin-based processes. These will challenge other materials and processes now in use. Propylene oxidation is a challenge to acetylene which accounts for about 70 percent of the acrylonitrile. (Propylene oxidation to acrolein is also a potential route to acrylonitrile and acrylates.) Methacrylates from isobutylene oxidation will be competing with the acetone cyanohydrin process, now the sole source.

Other contenders will also have to be reckoned with: ketene-formaldehyde for acrylates; acetaldehyde-HCN for acrylonitrile; and ethylene oxide-HCN for acrylonitrile and for acrylates.

ACRYLONITRILE PROCESSES

Process descriptions and flow sheets which are cited should provide a better understanding of acrylic process technology and relationships. Some of these are based on specific operations where noted, while others are generally representative of commercial practice.[2, 3, 4, 5, 6, 7, 8, 8a, 24]

ACRYLATE PROCESSES

Ethylene Cyanhydrin to Acrylonitrile and Acrylates. This process consists of the manufacture of ethylene cyanohydrin from ethylene oxide and HCN, followed by dehydration to acrylonitrile:

$$H_2C\!-\!CH_2 + HCN \rightarrow CH_2OHCH_2CN \rightarrow CH_2{=}CHCN + H_2O$$

(ethylene oxide: $H_2C\!-\!CH_2$ with O)

Ethylene Cyanohydrin. Ethylene oxide and HCN are reacted in the presence of an alkaline catalyst. One such operation uses the proportions 200 parts water, 8 parts diethylamine and 5 parts 50 percent NaOH. Ethylene oxide is introduced near the bottom of a cast iron reactor equipped with agitator and cooling coil. Liquid HCN is fed in near the liquid surface, with rates of addition controlled to maintain the temperature at 55° C. Total addition of ethylene oxide is usually 6-7 times the volume of water, requiring several hours. The temperature is raised to 65° C to complete the reaction and then the product is neutralized.[9]

• **Purification.** The crude ethylene cyanohydrin is purified by vacuum distillation (100-150 mm Hg). The overhead contains unconverted HCN, ethylene oxide and water; the bottoms consist of ethylene cyanohydrin of 88-90 percent purity.

• **Dehydration.** Conversion of the cyanohydrin to acrylonitrile is readily accomplished in the liquid phase. A variety of solid catalysts such as magnesium carbonate

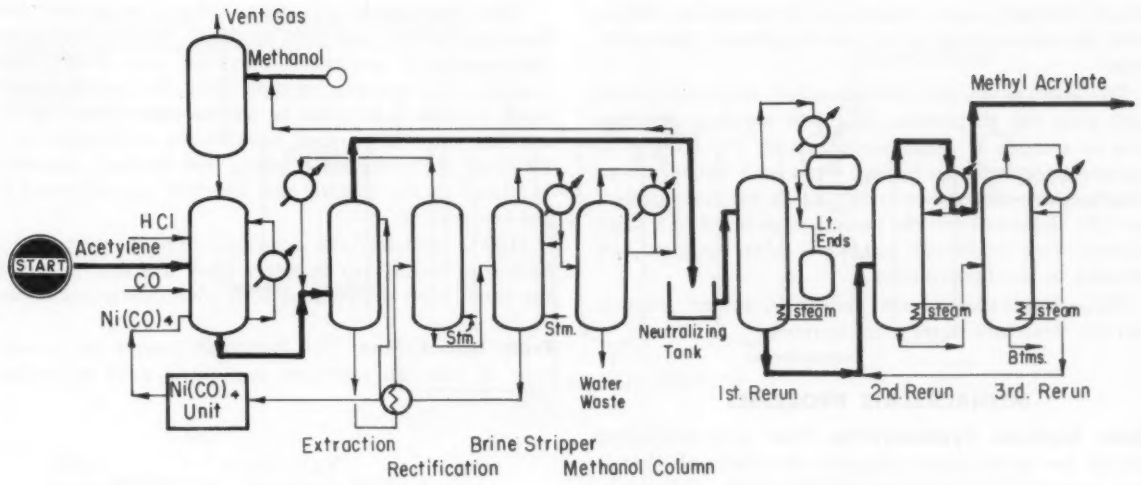


FIGURE 2—Rohm & Haas uses this general arrangement for methyl acrylate from acetylene.

may be used, but hydrolysis must be avoided. Under agitation at a temperature of 200° C, acrylonitrile and water come off overhead. The condensed organic layer is then fractionated to give purified acrylonitrile.

Manufacture of Acrylates. Ethylene cyanohydrin made as described above is hydrolyzed with sulfuric acid and then esterified to give the desired acrylate ester. The over-all reactions are:

$$CH_2OHCH_2CN \xrightarrow{H_2SO_4} CH_2=CHCONH_2 \cdot H_2SO_4$$

$$\xrightarrow{ROH} CH_2=CHCOOR + NH_4HSO_4$$

The hydrolysis-esterification reaction takes place in a lead-lined reactor surmounted by a packed dephlegmator column as shown in Figure 1. The reactor contents are at 150° C and maintained at constant volume. Vaporized alcohol (e.g. methanol) is fed at an 85 percent strength, the diluent water helping to suppress ether formation and polymerization. The product vapors are scrubbed by a mixture of ethylene cyanohydrin and sulfuric acid (75-80 percent) as they trickle down into the reactor. The molar ratios employed are 1 part cyanohydrin to 2 parts each of acid and alcohol.[10]

• **Separation.** The reactor vapors are cooled to 80° C then go to a hot water scrubber-dephlegmator. The methanol emerges as a dilute 3-5 percent solution, which is fractionated for recycle. Exit vapors containing the acrylate ester are condensed, washed and separated. The organic layers are combined and purified by fractionation at atmospheric pressure. The over-all yield based on ethylene cyanohydrin is about 80 percent.

Procedures vary according to the ester required. Acrylic acid can also be produced by omitting the esterification, in a simplified procedure.

Acrylates from Ketene-Formaldehyde. This method discovered by B. F. Goodrich and used by Celanese is a general type between various carbonyl compounds and various ketenes. The reaction takes place at relatively low temperatures using a catalyst of the Friedel-Crafts type. Yields are about 90 percent and the product is claimed to be extremely pure.[11]

The reactions to make acrylates are:

$$CH_2=C=O + HCHO \rightarrow CH_2-CH_2-C=O$$
$$\qquad\qquad\qquad\qquad\qquad\quad \underset{\text{O}}{\text{|}}\!\!\_\_\_\_\_\!\!\text{|}$$

$$\xrightarrow{ROH} CH_2=CHCOOR + H_2O$$

A slight excess of formaldehyde over ketene is used in the first step to make the β-lactone. In the second step, this intermediate is heated with an alcohol in the presence of a dehydration catalyst, and distilled.

Acrylate from Acetylene (Rohm & Haas Process). Acetylene is reacted with CO supplied in part by nickel carbonyl and mostly (about 80 percent) by CO itself. The over-all reaction may be represented as follows:

$$4HC \equiv CH + (CO) + Ni(CO)_4 + 4ROH + 2HCl \rightarrow$$

$$4CH_2=CHCOOR + NiCl_2 + H_2$$

The process has been described in detail[12,13] and is shown in Figure 2. The reaction occurs rapidly under mild conditions (30-50° C) in an agitated stainless steel reactor. The reactants, except for the alcohol, are introduced below the surface. An excess of alcohol is used to reduce viscosity and promote the reaction. It is introduced after being used to scrub the gases coming from the reactor. Acetylene is maintained in slight excess relative to the total CO used.

From the reactor the liquid product is cooled to prevent polymerization and then fed to a packed extraction column. A nickel chloride solution entering the top of the column extracts the alcohol and salts out the acrylate. The alcohol extract goes to a series of distillation columns to recover and concentrate the alcohol for recycle to the reactor. Nickel chloride brine from the bot-

tom of the last column returns to the extraction column with the excess going to the nickel carbonyl production unit.

The acrylate stream from extraction after neutralizing with soda ash to remove HCl and acrylic acid, then goes to a series of distillation columns: (1) Topped to remove light ends, including water and hydrocarbons (2) Acrylate ester taken overhead as finished product and (3) Bottoms from the second stage is fed to a third column where additional acrylate is taken overhead and recycled to the first column.

These fractionations are performed under vacumn, and the condenser water is refrigerated.

METHACRYLATE PROCESSES

From Acetone Cyanohydrin. This long-established process for methacrylates supplies essentially all that is now produced. It is based on formation of acetone cyanohydrin, which is then dehydrated, hydrolyzed and esterified:

$$(CH_3)_2CO + HCN \rightarrow (CH_3)_2COHCN \xrightarrow{H_2SO_4} CH_2=$$

$$\begin{matrix} CH_3 \\ | \\ C-CONH_2 \cdot H_2SO_4 \end{matrix} \xrightarrow{ROH} \begin{matrix} CH_3 \\ | \\ CH_2=C-COOR \end{matrix} + NH_4HSO_4$$

Acetone cyanohydrin is formed from acetone and HCN in the presence of an alkaline catalyst such as sodium hydroxide or sodium cyanide.

Because the reaction is exothermic, the rate depends on the contact efficiency and reactor cooling capacity. Gaseous HCN is passed into the reactor containing the acetone and the catalyst. The yield is about 88 percent based on HCN and 90-92 percent based on acetone.[14] The product, about 90 percent cyanohydrin, is neutralized at low temperatures either with sulfuric or phosphoric acid. Then it is further concentrated to about 97 percent by removing volatiles, using vacuum or inert gas.

The purified acetone cyanohydrin goes to a hydrolysis kettle where at 110-120° C it is dehydrated and partly hydrolyzed with sulfuric acid to form methacrylamide sulfate (See Figure 3). The mixture containing the intermediate is cooled to about 90° C for esterification with alcohol.

The crude produce is steam stripped to remove ammonium sulfate, and then rectified. Methacrylate ester and methanol are taken overhead and then water washed. The aqueous solution from the bottom of the wash column is recycled to the rectifier. Crude methacrylate ester is purified by vacuum distillation in a series of three columns, taking the finished monomer overhead in the second, and recycling the overhead in the last column.

Higher methacrylates are made from acetone cyanohydrin in a different manner. They are first esterified the ester, then dehydrated with phosphorus pentoxide.

From Isobutylene. The Escambia process uses a mixture of nitrogen tetroxide and nitric acid to oxidize isobutylene:[15]

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!>\!C=CH_2 \xrightarrow{N_2O_4} \begin{matrix} CH_3 \\ CH_3 \end{matrix}\!\!>\!\begin{matrix} OH \\ | \\ C-COOH \end{matrix} \xrightarrow{ROH}$$

$$\begin{matrix} CH_3 \\ | \\ CH_2=C-COOR \end{matrix} + H_2O$$

ACROLEIN PROCESSES

Shell Chemical Process. The process as developed by Shell makes use of air oxidation of propylene over a cuprous oxide catalyst. The reaction for the process shown in Figure 4 is:

$$CH_2=CHCH_3 + O_2 \rightarrow CH_2=CHCHO + H_2O$$

The propylene, which may be dilute, is used in about a fourfold excess over the oxygen content in the reactor feed gas. The percent of oxygen in the feed is usually below 10 percent for selectivity and to maintain the catalyst in the cuprous state. Steam is usually added as a diluent.[16]

Moderate pressure (to 10 atmospheres) may be used and temperatures of 300-350° C are preferred, with a corresponding contact time of 1-3 seconds. Propylene conversion per pass is about 20-30 percent.

The effluent gases are cooled and then water scrubbed to recover water-soluble products, chiefly acrolein.[17] The scrubbed gases go to a propylene recovery system for recycle. The acrolein is recovered from its dilute aqueous solution in a series of three fractionations:

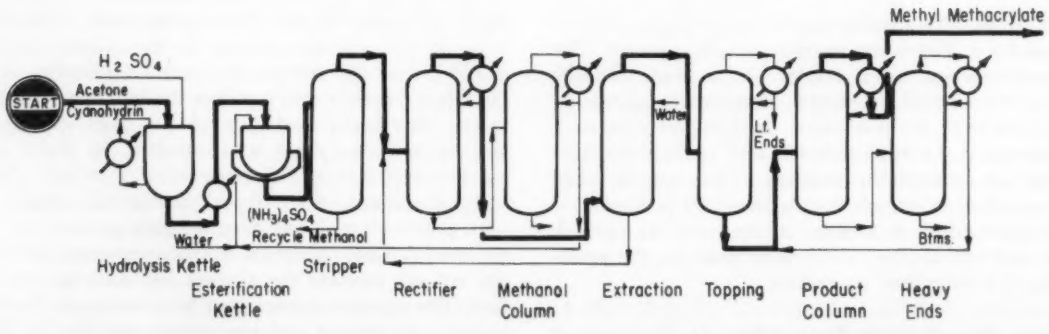


FIGURE 3—Starting with acetone cyanohydrin, this arrangement produces methyl methacrylate.

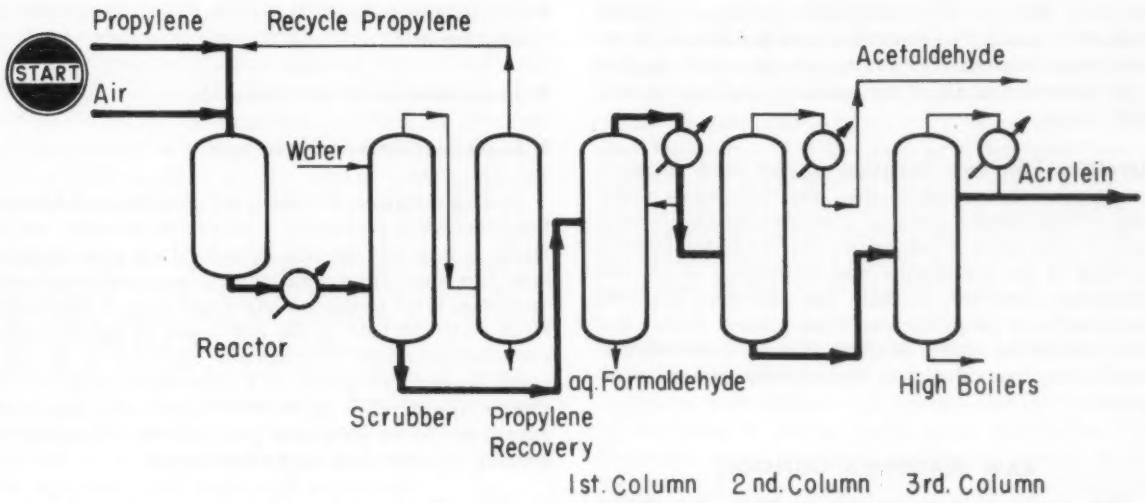


FIGURE 4—Shell's acrolein process uses cuprous oxide catalyst to make formaldehyde, acetaldehyde, and acrolein.

1. Recovery in the overhead together with acetaldehyde,
2. Recovery in the bottoms with acetaldehyde overhead, and
3. Purification as overhead in the final column

Cross Condensation. This vapor phase reaction consists of the condensation of acetaldehyde and formaldehyde, followed by dehydration:

$$CH_3CHO + HCHO \rightarrow$$

$$CH_3CHOHCHO \xrightarrow{-H_2O} CH_2 = CHCHO$$

Acetaldehyde and formalin (30 percent aq.) are mixed and vaporized before entering the reactor. A slight excess of acetaldehyde is used because of the recovery problem with formaldehyde; however excessive amounts of acetaldehyde tend to form crotonaldehyde as a byproduct. Two catalysts have been used: sodium silicate on silca gel or lithium phosphate on activated alumina. Conversions are 40-50 percent per pass with yields of 75-80 percent.[18]

• **Purification.** This usually entails (1) water scrubbing and fractionation to remove and recover the formaldehyde and (2) fractionation to separate the acetaldehyde from the acrolein.

PROCESS COMPARISON

To compare acrylics processing under widely differing conditions in a period of rapid technological change may not be especially meaningful. However, the activities cited could help shed some light on forthcoming trends.[19]

Acrylates Manufacture. Though acetylene processes account for the majority of acrylates made, the choice in the past 3 years has been between an acetylene-carbon monoxide process such as used by Rohm & Haas or by Dow-Badische, and the ketene-formaldehyde process developed by Goodrich and put to commercial use by Celanese. Expansions since 1958 have been divided almost equally between them. Union Carbide's process based on ethylene cyanohydrin was also expanded early in this period.

Which process to use has depended considerably on the plans and on the developments by the companies involved. Rohm & Haas developed and pioneered the acrylate from acetylene route in 1953 in its highly integrated Houston, Tex. plant. Dow in 1958 went to a similar type of process, availing itself of extensive acetylene knowhow it could share with its affiiliate Badische Anilin. However, Dow as the second largest producer of ethylene oxide, might well have been considering the ethylene cyanohydrin route. The top ethylene oxide producer, Union Carbide, can readily justify its use of this intermediate in acrylates, especially since it is also a route to acrylonitrile. For Celanese, acrylate manufacture by the ketene-formaldehyde route dovetails neatly with its large scale manufacture of these materials.

In addition to these varied situations, company decision may be guided by more than direct economic factors. Increasing emphasis has lately been going toward product purity, which affects polymerization rate and completeness of reaction and the properties of the polymer. This in the past has been a worrisome problem. Celanese in its recent advertising has been calling attention to the purity of its product, and other producers may have to show they can match this.

Methacrylates Manufacture. The new process based on isobutylene oxidation seems likely to make inroads even against the well-established technology of acetone cyanohydrin, first developed and licensed by Imperial Chemical Industries. Escambia, has carefully pilot planted its process and is now ready to tackle bigger producers using the established process. Should the venture prove itself, it will probably encourage others who are well fixed for isobutylene and interested in meth-

acrylates. Several other companies also have a patent position in making methacrolein from isobutylene. However, some important producers who are well supplied with acetone and HCN are probably inclined to stick with them.

Acrolein. Propylene oxidation appears more economical in most circumstances than the older route which uses a cross condensation of acetaldehyde and formaldehyde. The latter is the process used by Union Carbide because of the accessibility and abundance of the two aldehydes. However, Carbide has also been reported interested in a propylene oxidation process. Lower cost acetaldehyde becoming available directly from ethylene would help keep the cross condensation process competitive.

RAW MATERIALS OUTLOOK

The acrylic process outlook is being increasingly shaped not only by process changes but by trends in starting materials. Like many petrochemicals, the acrylics are dependent on the economics and availability of paraffinic and olefinic hydrocarbons and their immediate derivatives. It is therefore of interest to examine the status and trends in these acrylic building blocks.

Acetylene. Today the source of about 70 percent of the acrylonitrile, acetylene is likely to face strong future competition, with the advent of propylene oxidation and potential availability of the lactonitrile process. In acrylates, acetylene is challenged by the propiolactone process (ketene-formaldehyde). However, even though the latter has contributed equally to acrylate expansion since 1958, acetylene should continue to do comparatively well. Few companies would be so well supplied as Celanese with the materials required.

How acetylene fares in acrylics is partly dependent on two pairs of factors, one economic and the other technical: (1) Price trends in natural gas and power and (2) Improved acetylene technology and expansion of acetylene uses.

The first of these is on the debit side since these costs are still rising gradually. However, the second factor is more favorable with the pace in acetylene process technology continuing active, and with prospects of a breakthrough. For instance, earlier this year, Du Pont disclosed a significant reduction in power requirements using a new type of arc at its Montague, Mich. plant. Moreover, progress in acetylene chemistry leading to more diversification also improves the feasibility of acetylene manufacturing complexes for over-the-fence purchase. This should somewhat widen the choice of economic sites, and tend to offset the limitations of transportability.

Hydrogen Cyanide. Along with acetylene, HCN is the other current key material in acrylic manufacture. In fact its use is even more widespread, since it can be used in all three major acrylics:

- In acrylonitrile—with acetylene, acetaldehyde or ethylene oxide
- In acrylates—with ethylene oxide
- In methacrylates—with acetone

As with acetylene, the rising use of olefins and ketene-formaldehyde is potentially a barrier to increased use of HCN. It is doubly affected by natural gas price changes since it is made from methane and from methane-based ammonia. Price trends in natural gas make it likely that HCN costs will tend to rise and hence its use in acrylic manufacture might be gradually subject to an economic squeeze. However, as a convenient means to all three major acrylics, HCN offers sufficiently important advantages to an integrated producer that is outlook is actually stronger than might first appear.

Ethylene Oxide. While production increases in ethylene oxide use for acrylics has been limited, it will probably continue to contribute in a restricted but significant way to acrylic processing. Its use prospects stem from its versatility: It can be used to make either acrylonitrile or acrylates, and other products as well in a diversified operation. At the Union Carbide plant at Institute, W. Va., for instance, the output also goes for ethylene glycol and other important uses. Incremental costs for ethylene oxide makes it more attractive as a route to acrylics.

A handful of other ethylene oxide producers might also consider the route favorable, with the prospects generally improving relative to the amount of net available output. Dow's recent expansion of ethylene oxide capacity at Plaquemine, La. could be a means to acrylonitrile or acrylates, even though its 15 million-pounds/yr. plant at Freeport, Texas for the latter already uses acetylene.

Further expansion of ethylene oxide use in acrylics would be promoted by continuing improvement in selectivity in the ethylene oxide manufacturing process.

Acetaldehyde. Use in acrylics has been hindered by comparatively high production cost from acetylene hydration or ethyl alcohol oxidation. However, the Wacker process to make acetaldehyde directly from ethylene has recently become available. This development could reflect favorably on the status of the lactonitrile process to acrylonitrile, and conceivably raise the status of the cross condensation process to make acrolein.

In this connection it should be noted that Celanese is now building a 100 million-pounds/yr. plant at Bay City, Texas, and most of this output will be for acetaldehyde by the Wacker process.[20] Among other possibilities, this could be a forerunner to a Celanese move into acrylonitrile production.

Acetone/Acetic Acid. Acetone will continue as a major ingredient in methacrylates, though the isobutylene oxidation process looms as a stumbling block to

rapid growth. Either acetone or acetic acid could figure as ketene sources in the manufacture of acrylates by the Goodrich process. Greater acetone abundance from cumene phenol and other sources will further enhance the likelihood of its continued use. Another favorable prospect would be the proving out of a reported oxidation process to make acetone directly from propylene, analogous to the Wacker process for acetaldehyde.

Olefins should show the biggest increase in use among materials for future acrylic expansion. Propylene will be the biggest gainer through its oxidation to acrylonitrile and acrolein, and possibly also as a source for acetone. Isobutylene use will expand to the extent of its use in methacrylates and methacrolein. Ethylene use would be favorably affected through lower cost and greater availability of acetaldehyde or ethylene oxide, and also through lower cost acetic acid for ketene.

PRODUCERS—ACTION AND REACTION

Guided by such considerations, the different acrylic producers have applied them in their individual ways. The similarities and differences in these moves will perhaps best be illustrated by some examples.

Rohm & Haas. U.S. pioneer in acrylics, Rohm & Haas went into methacrylate production 25 years ago and has held a leading position ever since. Acrylate production began even earlier but the big expansion came in 1953 with the first integrated acrylate plant based on acetylene at Houston, Tex. To this day, Rohm & Haas continues to be the pacesetter in both methacrylates and in acrylates, despite challenge in the former by Du Pont and in the latter by Celanese. R&H is now expanding in methacrylates, and over-all has probably been the most active in promotion and development.

Du Pont. Besides being Rohm & Haas' chief competitor in methacrylates, Du Pont was also the trailblazer in acrylic fibers, introducing them in 1950. It has been the chief producer ever since, currently holding 60-65 percent of the total market. For nearly ten years, Du Pont purchased acrylonitrile from others. But since 1960 it has moved toward self-sufficiency. Last fall it started a 50 million lbs./yr. plant at Memphis based on acetylene-HCN; this year it is completing a second one of comparable size at Beaumont, Tex. based on its propylene oxidation process.

Du Pont has also been consolidating its future position with improved acetylene technology, and stepping up its development and promotional activities of acrylic paints and methacrylates.

American Cyanamid. A leading producer in acrylonitrile for over 10 years, American Cyanamid has relied almost entirely on acetylene-HCN since building its Fortier, La., plant in 1953. Before that it used the ethylene oxide-HCN route at Warner's, N. J., but this plant is reportedly in standby status. With some of its former customers turning producers, Cyanamid has swung over to captive acrylonitrile uses, one of which is its acrylic fiber introduced in 1959. Cyanamid has also been a leading figure in cyanoethylation research and in copolymers. With more HCN now available, the company is going into the methyl methacrylate field via acetone cyanohydrin. Recently it moved closer to the market by purchasing Wasco, an acrylic fabricator.

Monsanto. Like Cyanamid, Monsanto is a leading producer in acrylonitrile and active in cyanoethylation. Being also well supplied with acetone and HCN, it may be interested in methyl methacrylate production. But Monsanto is in a stronger position in acrylic fibers, through its Chemstrand subsidiary, which has captured some 25 percent of the acrylic fiber market. As a major styrene producer, the company is active in acrylonitrile copolymers and ABS terpolymers.

Dow. The leading styrene producer, Dow Chemical, has become interested and active in acrylic copolymers. Through its affiliate, Dow-Badische, the company has gone into acrylates via acetylene. Dow's own acrylic fiber is one reason to go into acrylonitrile, but the choice of processing remains to be seen. One of its most recent activities is in pushing development of promising olefin-acrylate copolymers.

Union Carbide. Though the only company now using ethylene oxide as a route to acrylonitrile and acrylates, Carbide is not just coasting. Like Dow, it has become active in olefin-acrylate copolymers. Carbide is well-fixed for olefins and acetylene, and was recently granted patents on use of acetylene and CO to make acrylates. Since 1955, Carbide has been active in acrolein by cross condensation but is also reported to be investigating propylene oxidation.

Shell's extensive activities in propylene and interest in acrolein have drawn it toward the acrylic orbit. Quite likely Shell is also aware that this could also be a stepping stone to acrylonitrile or acrylates. The company has also done some work in isobutylene oxidation, and has taken a leading part in the development of acrolein derivatives.

Sohio. The petroleum company most active in propylene oxidation is Sohio which last year pioneered the first U.S. acrylonitrile plant based on air oxidation of propylene in the presence of ammonia. Since then, Sohio has been busy in the U.S. and abroad seeking licensees for this process. The company also holds patents on acrolein from air oxidation of propylene.

Escambia. A joint venture company making a relatively fresh start in petrochemicals, Escambia has resorted to a

different approach than most other producers. The isobutylene route to methyl methacrylate evolved from this research-oriented viewpoint. The company has also pilot planted an acrylonitrile process, and probably is interested in other olefins as raw material.

Goodrich. The position of Goodrich in acrylics might be characterized as being stronger technologically than its position in raw materials could readily exploit. Goodrich developed the ketene-formaldehyde process, but not being in position to capitalize on it fully, licensed it to Celanese. (In its own manufacture of acrylonitrile, the company buys acetylene at Calvert City, Ky.) Goodrich has been active in product and market development of acrylonitrile uses. Its output is practically 100 percent captive including ABS plastics, nitrile rubber, and several more.

Celanese. Owing to its strong position in acetyls, Celanese has best been able to prifit by the Goodrich process. Celanese acrylate output is now about on a par with Rohm & Haas, though it implies advantages in purity over other producers. Celanese is also likely to be interested in other acrylics. With increased availability and lower cost of acetaldehyde, it could well be the first to use the lactonitrile process, or be successful with the cross condensation route to acrolein.

Others. A number of other companies have shown varying degrees of interest in one or more of the acrylics. Among them are: Hercules, Allied Diamond, Olin, Phillips and Sinclair.
(Table 1 lists the acrylic producers and their estimated capacities).

TABLE 1—U.S. Acrylic Producers and Estimated Capacities
(Million Lbs./Year as of Early 1962 Unless Otherwise Noted)

Producer	Acrylonitrile	Acrylates	Methacrylates	Acrolein
Rohm & Haas	... ...	30 D	135 F	.. ..
DuPont	100 A, B	.. ..	75 F	.. ..
American Cyanamid	100 A	.. ..	*30 F	.. ..
Monsanto Chemical	100 A	.. ..	... ..	.. ..
Union Carbide	70 C	15 C	... ..	15 H
B. F. Goodrich	35 A	5 E	... ..	.. ..
Celanese Chemical	... ..	30 E	... ..	.. ..
Standard Oil (Ohio)	45 B	.. ..	... ..	.. ..
Dow-Badische	... ...	15 D	... ..	.. ..
Escambia	... ...	.. ..	*25 G	.. ..
Shell Chemical	... .	.. ..	... ..	**50 B
Total	450	95	265	60

Process Code:
A —Acetylene + HCN
B —Propylene
C —Ethylene Cyanohydrin
D —Acetylene + CO
E —Ketene + Formaldehyde
F —Acetone Cyanohydrin
G —Isobutylene
H —Acetaldehyde + Formaldehyde

* Early 1963
** More than Half for Glycerine Mfr.

PAVING THE WAY

By their actions, most producers indicate they realize that though a wise process selection can be very helpful, it is not a guarantee of acrylic success. Whatever the process they use, most are also conducting intensive development in products and markets. In this endeavor also is the more numerous group of acrylic converters.

Those participating in this development drive find that the acrylics give them ample scope, for they not only have many inherently desirable properties, but also offer an unusual range to choose from. The various esters of acrylates and methacrylates cover the gamut from liquids to elastomers to hard plastics.

Among other assets, the acrylics in general can impart chemical resistance, heat resistance, and outstanding weatherability. Methacrylates in addition possess abrasion resistance and optical clarity; acrylic emulsions exhibit excellent stability and film-forming properties.

Moreover, the acrylics are capable of extensive modification with other plastics or elastomers, either in copolymers or physical blends. Some of the more important are with styrene, with vinyl acetate, and with polyesters. This compatibility permits more formulation leeway in performance and in cost.

Product development has resulted in a number of new or improved types:

- Thermosetting polymers through other functional groups and cross-linking
- Improved stretch and physical properties by orientation
- Improved impact resistance and heat resistance
- New copolymer types such as olefin-acrylates and polyvinylpyrrolidone (PVP) copolymers
- New derivatives of, and uses for, acrolein and acrylamide

CHIEF PRODUCT PROSPECTS

Despite the activity in newer development areas, the immediate hopes of the acrylic producers will continue to ride with the growth in demand for the three acrylic mainstays, though with increasing help from the newer products. In view of their importance, the uses and prospects of the major products are:

Acrylonitrile. For the past eight years, acrylic fibers has been the principal outlet and increasingly so. Demand for these fibers climbed from 10 million pounds in 1952 to around 200 million this year. In competition with nylon, polyesters, and other synthetics, acrylics have now captured over 20 percent of the total.[22]

Present indications are that the acrylic fibers will rise to about 25 percent of the synthetic fiber market by 1965.

Fiber Treatments. Acrylonitrile's versatility will enable it to benefit even if the competitive position of the natural fibers should be enhanced. For this acrylic is being used on a development scale for physical and for chemical treatment of such fibers as cotton, wool, paper, wood and jute to upgrade their properties. The chemical treatment known as cyanoethylation, under development largely by American Cyanamid and Monsanto, is probably the most important. The potential could be

considerable though large scale application is probably 5-10 years away. One commercial breakthrough has already been achieved: an exceptional dielectric with future application to electroluminescence. Physical treatments have present or potential application in wash-and-wear fabrics, and in better resistance to fiber abrasion.

Copolymers

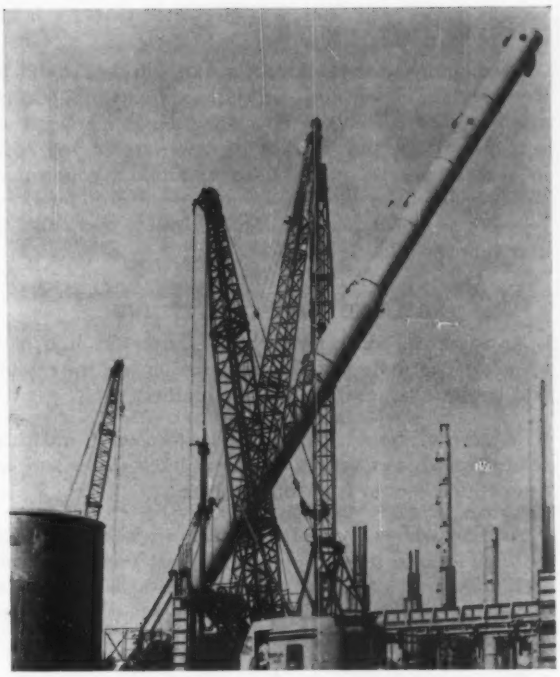
• **Nitrile Rubber,** after its booming World War II use in aircraft selfsealing fuel tanks, went into a slump for a few years followed by a gradual recovery. The pace has been stepping up in recent years as product improvement, diversification and application have started to pay off. Its use has approximately doubled since 1954. Fabricated rubber goods is the chief outlet, with modification by butadiene, polyvinyl chloride and phenolics, as well as development of cold nitrile rubber. Latex is coming in for greater attention, with Goodrich expecting the biggest growth in the textile field.

• **Styrene Copolymers** have become increasingly important in acrylonitrile prospects, by serving to reduce cost or improve performance. Some of the most active in this area are Dow, Monsanto, Union Carbide and American Cyanamid. Use of styrene copolymers rose from 13.6 million lbs. in 1955 to 32.2 million lbs. in 1959, with no letdown in sight. Acrylonitrile has also been finding increasing use in styrene syrups which speed up the curing and improve the properties of polyesters and alkyds.

ABS Terpolymers. These products fill the need for a low-cost, all-round plastic that is tough, moldable and with good environmental resistance. Total use between now and 1965 is expected to more than double. U.S. Rubber and Marbon division of Borg-Warner were the first companies in this field, but Goodrich and Monsanto have become increasingly active in production and development. Union Carbide and Dow are among the likely prospects to join them.

Other possibilities. More acrylonitrile copolymers are being investigated; those with polyvinylpyrrolidone (PVP) and with methyl styrene are some of the more promising. Monosodium glutamate (MSG) food flavoring will soon be made from acrylonitrile in a Japanese unit having some 300 tons per mo. capacity. Among the acrylonitrile derivatives, acrylamide is establishing itself in a number of industrial uses such as textile treatments, water flocculation, soil conditioning and in a variety of comonomers.

Acrylates. Continued high expectations for acrylates are based in large measure on its stability and film-forming ability in emulsions, and on its compatibility in polymers and blends. These qualities and its weather-resistance are especially needed in latex paints, which have been in a steep rise originally for interior use, and more recently for the exterior as well. In the first, their popularity stems from easy application and quick drying; in the second, weatherability is the prime factor in their selection. Besides the household market, acrylate coatings for industrial uses and maintenance are also expected to grow because of their convenience, durability and safety.



Sohio was the first onstream with a propylene oxidation process for making acrylonitrile. Its Lima plant was completed in 1960.

Acrylate emulsions in floor polishes have met quick acceptance due to their self-polishing features, non-yellowing and resistance to water and scuffing.

To meet this demand for acrylic emulsions a score of plants have gone into production including 4 by Borden Chemical and 3 by Monsanto. These companies will be concentrating mainly on these two applications, which will probably grow some 18 percent annually in the next five years. Other uses in leather, textile, paper and adhesives will also be growing but at a more moderate pace.

A trend to acrylate copolymers can be expected, aimed for better performance, lower cost and for a broader range of tailor-made products. Among these copolymers are: (1) with styrene for better solvent resistance; (2) with vinyls for internal plasticizing; (3) with olefins for combined resilience and crack resistance; (4) with methacrylates for harder surface coatings.

Methacrylates. In addition to possessing the general characteristics of the acrylics, methyl methacrylate polymers have outstanding optical properties. This combination of properties make it an ideal choice in glazing where breakage or maintenance is a problem, and clarity and weather resistance are desired. The next five years is likely to see considerable growth in methyl methacrylate use for skylights, partitions and panels. Plastic signs, the biggest use today, should do just about as well in this period. Cast and molded products due to grow include extrusions for automotive uses; shapes

such as domes and lenses; and fabricated parts for lighting applications.

Accompanying these advances also will be a trend to methacrylate copolymers, including styrene copolymers, and styrene-methacrylate syrups for use in combination with polyesters, and a sharp increase is expected both in latex and in lacquer copolymer finishes, copolymers with acrylates should continue to expand in automotive lacquers and in appliances. Thermosetting types should also gain markedly.

RELATED AND COMPETITIVE

As acrylic products grow and branch out into new areas they encounter additional varieties of competition and become linked in new opportunities:

- In acrylic fibers competition is expected to intensify as new producers seek a larger market share and as competition sets in from other fibers.

- Acrylics will be vying for markets with such plastics as high-impact styrene, polypropylene, and cellulose acetate-butyrate. Coating competition will be felt in solvent types largely by alkyds and in latex, by butadiene-styrene and by vinyl acetate types.

- Foreign producers who hope to take a more active part in the U.S. market, include Imperial Chemical Industries, Distillers Co. Ltd, Ugilor and Hoechst.

- Process licensing is on the increase with Distillers Co. in Europe and Sohio showing particular activity in acrylonitrile from propylene processes.

- Product licensing is beginning to assume some importance, with thermosetting and thermoplastic acrylics licensed by Pittsburgh Plate Glass, being only one example.

THE FUTURE LOOKS BRIGHT

During the past 25 years, the premium qualities and versatility of the acrylics have come to be well-known. They have already shown their capabilities in such successes as the rise of the acrylic fibers, nitrile rubber, acrylate latex paints, and methyl methacrylate plastics. To this proof of potential and performance can now be added the cumulative benefits of lower cost processes and materials; new products; improved modifications and broader markets. In addition, new dimensions are being added through acrolein and acrylic derivatives. Small wonder that well-prepared producers involved with this prolific family face the future with optimism.

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Key Words for Indexing

Acetal Resins
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Acrolein
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Acrylonitrile
Acrylonitrile-Butadiene-Styrene Plastics
Agitators
Air
Ammonia
Capacity
Carbon Monoxide
Catalysts
Chlorides/Inorganic
Diethylamine
Elastomers
Esters
Ethylene
Ethylene Cyanohydrin
Ethylene Oxide
Fibers
Formaldehyde
Furnaces
Hydrogen Chloride
Hydrogen Cyanide
Methacrylates
Methanol
Methyl Acrylate
Methyl Methacrylate
Nickel Carbonyl
Nitrile-Rubber
Oxygen
Phosphoric Acid
Plastics
Polyesters
Propylene
Reactors
Rubber
Sodium Carbonate
Sodium Cyanide
Sodium Hydroxide
Styrene
Sulfuric Acid
Wool

Thermo Data for Petrochemicals

Part 31: Gaseous Normal 2-thia Alkanes. The important thermo properties are presented for all gaseous n-2-thia alkanes from dimethylsulfide through methyl-n-decasulfide

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Heat of Formation. The heats of formation of dimethylsulfide,[1] methyl-ethylsulfide,[2] and methyl-n-propylsulfide[3] are given in the literature. These data were calculated from measured heats of combustion. The heats of formation, after a slight correction for a recent redetermination[4] of the heat effect of the reaction

$$s(rh) + 56\,H_2O(l) + \frac{3}{2}\,O_2(g) \rightarrow H_2SO_4 \cdot 55\,H_2O(l)$$

are given in Table 1.

If we calculate the heat effect ΔH°_r of the process

$$CH_3 - S - C_nH_{2n+1}(g) + 2\,H_2(g) \rightarrow$$
$$CH_4(g) + C_nH_{2n+2}(g) + H_2S(g)$$

we find at 25 °C

$$CH_3 - S - CH_3 : \Delta H^\circ_r = -31.62 \pm 0.23 \frac{kcal}{mole}$$

$$CH_3 - S - C_2H_5 : \Delta H^\circ_r = -28.73 \pm 0.34 \frac{kcal}{mole}$$

$$CH_3 - S - C_3H_7 : \Delta H^\circ_r = -28.02 \pm 0.34 \frac{kcal}{mole}$$

Plotting these heats of reaction versus the number of C atoms in the thia alkane molecule we find (extrapolating slightly), for $n > 4$, a constant heat of reaction; i.e.

$$25\ ^\circ C\ n > 3\ \Delta H^\circ_7 = -28.25 \pm 0.34 \frac{kcal}{mole}$$

Using this constant heat of reaction for $n > 4$ we may write for the heat of formation of the gaseous n-2-thia alkane at 25° C

$$\Delta H^\circ_{f CH_3SC_nH_{2n+1}} = \underbrace{5.54 + \Delta H^\circ_{f C_nH_{2n+2}}}_{\text{Reference state S(rh)}} = \underbrace{-9.88 + \Delta H^\circ_{f C_nH_{2n+2}}}_{\text{Reference state } S_2(g)} \quad *$$

With the help of these formulas the heats of formation of the higher homologs in the gaseous state were calculated, the results are given in Table 1.

*Heats of formation of the gaseous n-alkanes were taken from Rossini[10]

Table 1

2-Thia-alkane		Reference State S(rh) $\Delta H^\circ_{f\ 298.15\ ^\circ K}$ kcal/mole	Reference State $S_2(g)$ $\Delta H^\circ_{f\ 298.15\ ^\circ K}$ kcal/mole	Literature
CH_3-S-CH_3	(l)	−15.64 ± 0.16	.....	1
	(g)	− 8.98 ± 0.16	−24.40 ± 0.18	
$CH_3-S-C_2H_5$	(l)	−21.86 ± 0.27	.....	2
	(g)	−14.22 ± 0.27	−29.46 ± 0.29	2
$CH_3-S-C_3H_7$	(l)	−28.18 ± 0.22	.....	3
	(g)	−19.51 ± 0.23	−34.93 ± 0.25	3
$CH_3-S-C_4H_9$	(g)	−24.61 ± 0.28	−40.03 ± 0.30	
$CH_3-S-C_5H_{11}$	(g)	−29.46 ± 0.33	−44.88 ± 0.35	
$CH_3-S-C_6H_{13}$	(g)	−34.42 ± 0.38	−49.84 ± 0.40	Inaccuracy estimated
$CH_3-S-C_7H_{15}$	(g)	−39.35 ± 0.43	−54.77 ± 0.45	
$CH_3-S-C_8H_{17}$	(g)	−44.28 ± 0.48	−59.70 ± 0.50	
$CH_3-S-C_9H_{19}$	(g)	−49.20 ± 0.53	−64.62 ± 0.55	
$CH_3-S-C_{10}H_{21}$	(g)	−54.13 ± 0.58	−69.55 ± 0.60	

Entropy. The entropies of dimethylsulfide,[1] methyl-ethylsulfide[5] and methyl-n-propylsulfide at 25° C can be found in the literature. The data are collected in Table 2.

Table 2

2-Thia-alkane		$S^\circ_{298.15}$ cal/mole °K	Literature	
CH_3-S-CH_3	(l)	46.94 ± 0.07	1	12
	(g)	68.32 ± 0.09	1	12
$CH_3-S-C_2H_5$	(l)	57.14 ± 0.10	5	
	(g)	79.62 ± 0.20	5	
$CH_3-S-C_3H_7$	(l)	65.14 ± 0.13	6	
	(g)	89.05 ± 0.20		

THERMODYNAMIC PROPERTIES AS A FUNCTION OF TEMPERATURE

Dimethylsulfide. Thermodynamic properties of dimethylsulfide are measured and calculated by the U.S. Bureau of Mines thermodynamics group.[1] The values thus found are given in the Tables 4, 5, 6 and 7.

Methyl-ethylsulfide. The thermodynamic data of this compound are also measured and calculated by the U.S. Bureau of Mines thermodynamics group.[5,7] The values resulting from the group's work are given in the Tables 4, 5, 6 and 7.

Methyl-n-propylsulfide. Thermodynamic data as a function of temperature are calculated by the U.S. Bureau of Mines thermodynamics group[6] using a "refined method of increments." In this article we propose to use the "normal method of increments" using the gaseous normal alkanes as reference compounds, i.e.

$$\phi(CH_3 - S - C_3H_7) =$$
$$\phi(CH_3 - S - C_2H_5) + \phi(C_5H_{12}) - \phi(C_4H_{10})$$

Using this way of calculation we find (see Table 3)

Table 3

Entropy cal/mole °K			Heat Capacity cal/mole °K		
Temp. °K	S° meas. [6]	S° calc.	Temp. °K	C°_p meas. [6]	C°_p calc.
328.12	91.62 ± 0.2	91.61	400	34.64	34.74
347.02	93.32 ± 0.2	93.30	500	40.61	40.64
368.70	95.26 ± 0.2	95.26			

Though the U.S. Bureau of Mines group claim a *reproducibility* of better than 0.1 percent of their measured heat capacity data, we believe that the *absolute accuracy* of the measured heat capacity data is of the order of 0.1 $\frac{\text{cal}}{\text{mol °K}}$. If one accepts this estimation of the absolute accuracy, bearing in mind the accuracy of thermodynamic functions of the normal alkanes used in the calculations, the agreement shown in Table 3 is as good as can be expected. Thermodynamic properties of methyl-n-propylsulfide, calculated as indicated above, are given in the Tables 4, 5, 6 and 7.

The Higher Homologs. The thermodynamic functions of the higher homologs are calculated by a "normal method of increments," i.e.

$$\phi(CH_3-S-C_nH_{2n+1}) = \phi(CH_3-S-C_3H_7) + \phi(C_{n+2}H_{2n+6}) - \phi(C_5H_{12})\ n > 3$$

the thermodynamic functions calculated are presented in the Tables 4, 5, 6 and 7. Thermodynamic functions of the normal gaseous alkanes used in the incremental calculations were taken from the well-known paper of Person and Pimentel.[8]

HEAT OF FORMATION AND FREE ENTHALPY OF FORMATION

Using values of $\frac{H°-H°_o}{T}$ and $\frac{G°-H°_o}{T}$ given in the Tables 5 and 6, in combination with the corresponding functions of C (graphite)[10], $S_2(g)$[11] and $H_2(g)$[10] we calculated the heat of formation and free enthalpy of formation of the gaseous n-2-thia alkanes. The values thus calculated are given in Table 8 and 9.

Starting from the free enthalpy of formation given in

Table 4

Compound	TEMPERATURE °K										
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Heat Capacity $C°_p$ $\frac{\text{cal}}{\text{mole °K}}$										
CH_3-S-CH_3	0	16.86	17.71	17.77	21.12	24.24	27.01	29.44	31.59	33.50	35.17
$CH_3-S-C_2H_5$	0	21.49	22.73	22.82	27.81	32.40	36.41	39.89	42.93	45.60	47.94
$CH_3-S-C_3H_7$	0	26.61	28.17	28.29	34.74	40.64	45.75	50.17	54.00	57.34	60.27
$CH_3-S-C_4H_9$	0	31.72	33.64	33.79	41.68	48.89	55.10	60.44	65.06	69.09	72.61
$CH_3-S-C_5H_{11}$	0	36.84	39.11	39.28	48.63	57.13	64.44	70.72	76.13	80.84	84.94
$CH_3-S-C_6H_{13}$	0	41.96	44.58	44.77	55.57	65.38	73.78	81.00	87.20	92.59	97.27
$CH_3-S-C_7H_{15}$	0	47.18	50.04	50.27	62.51	73.62	83.12	91.27	98.26	104.33	109.61
$CH_3-S-C_8H_{17}$	0	52.29	55.51	55.76	69.45	81.87	92.47	101.55	109.33	116.08	121.94
$CH_3-S-C_9H_{19}$	0	57.41	60.97	61.26	76.39	90.11	101.81	111.82	120.39	127.82	134.27
$CH_3-S-C_{10}H_{21}$	0	62.53	66.44	66.75	83.34	98.36	111.15	122.10	131.46	139.57	146.61

* The values in this and the following tables are given to more significant figures than is justified by the accuracy of the calculations.

Table 5

Compound	TEMPERATURE °K										
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Enthalpy Function $\frac{H°-H°_0}{T}$ $\frac{\text{cal}}{\text{mole °K}}$										
CH_3-S-CH_3	0	11.69	12.13	12.16	13.94	15.70	17.38	18.96	20.44	21.81	23.08
$CH_3-S-C_2H_5$	0	14.75	15.37	15.42	17.89	20.35	22.68	24.90	26.95	28.88	30.68
$CH_3-S-C_3H_7$	0	17.90	18.70	18.73	21.92	25.10	28.10	30.94	33.58	36.04	38.33
$CH_3-S-C_4H_9$	0	21.05	22.03	22.08	25.99	29.88	33.54	37.01	40.22	43.22	45.99
$CH_3-S-C_5H_{11}$	0	24.20	25.36	25.42	30.05	34.65	38.98	43.07	46.87	50.40	53.66
$CH_3-S-C_6H_{13}$	0	27.35	28.69	28.76	34.11	39.42	44.42	49.13	53.51	57.58	61.32
$CH_3-S-C_7H_{15}$	0	30.51	32.02	32.11	38.18	44.20	49.86	55.19	60.16	64.75	68.99
$CH_3-S-C_8H_{17}$	0	33.66	35.35	35.45	42.24	48.97	55.30	61.26	66.80	71.93	76.65
$CH_3-S-C_9H_{19}$	0	36.82	38.68	38.80	46.30	53.75	60.74	67.32	73.44	79.10	84.22
$CH_3-S-C_{10}H_{21}$	0	39.98	42.01	42.14	50.37	58.55	66.18	73.38	80.09	86.28	91.88

Table 6

Compound	TEMPERATURE °K										
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Free Enthalpy Function $\frac{G°-H°_0}{T}$ $\frac{\text{cal}}{\text{mole °K}}$										
CH_3-S-CH_3	0	— 57.60	— 58.64	— 58.72	— 62.46	— 65.76	— 68.78	— 71.58	— 74.21	— 76.69	— 79.07
$CH_3-S-C_2H_5$	0	— 62.92	— 64.25	— 64.34	— 69.11	— 73.37	— 77.30	— 80.96	— 84.42	— 87.72	— 90.85
$CH_3-S-C_3H_7$	0	— 68.63	— 70.35	— 70.51	— 76.33	— 81.55	— 86.42	— 90.97	— 95.28	— 99.38	—103.30
$CH_3-S-C_4H_9$	0	— 74.42	— 76.43	— 76.62	— 83.48	— 89.69	— 95.49	—100.92	—106.09	—110.99	—115.70
$CH_3-S-C_5H_{11}$	0	— 80.22	— 82.51	— 82.72	— 90.64	— 97.84	—104.56	—110.88	—116.89	—122.60	—128.09
$CH_3-S-C_6H_{13}$	0	— 85.92	— 88.49	— 88.73	— 97.71	—105.88	—113.53	—120.74	—127.60	—134.12	—140.40
$CH_3-S-C_7H_{15}$	0	— 91.61	— 94.47	— 94.72	—104.76	—113.92	—122.50	—130.59	—138.29	—145.63	—152.69
$CH_3-S-C_8H_{17}$	0	— 97.20	—100.45	—100.72	—111.82	—121.97	—131.47	—140.44	—149.00	—157.15	—164.90
$CH_3-S-C_9H_{19}$	0	—102.99	—106.43	—106.72	—118.89	—130.01	—140.44	—150.30	—159.71	—168.66	—177.19
$CH_3-S-C_{10}H_{21}$	0	—108.68	—112.40	—112.72	—125.95	—138.05	—149.40	—160.16	—170.41	—180.18	—189.49

Table 7

Compound	TEMPERATURE °K									
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Entropy S° — cal / mole °K										
CH_3–S–CH_3	0	69.29	70.77	70.88	76.40	81.46	86.16	90.54	94.65	95.98	102.15
CH_3–S–C_2H_5	0	77.68	79.62	79.76	87.00	93.71	99.98	105.86	111.38	116.60	121.53
CH_3–S–C_3H_7	0	86.53	89.05	89.24	98.25	106.65	114.52	121.91	128.86	135.42	141.63
CH_3–S–C_4H_9	0	95.47	98.46	98.70	109.47	119.57	129.03	137.93	146.31	154.21	161.69
CH_3–S–C_5H_{11}	0	104.42	107.87	108.14	120.69	132.49	143.54	153.95	163.76	173.00	181.75
CH_3–S–C_6H_{13}	0	113.27	117.18	117.49	131.82	145.30	157.95	169.87	181.11	191.69	201.72
CH_3–S–C_7H_{15}	0	122.12	126.49	126.83	142.94	158.12	172.36	185.78	198.45	210.39	221.68
CH_3–S–C_8H_{17}	0	130.96	135.80	136.17	154.06	170.94	186.77	201.70	215.80	229.08	241.64
CH_3–S–C_9H_{19}	0	139.81	145.11	145.52	165.19	183.76	201.18	217.62	233.15	247.76	261.61
CH_3–S–$C_{10}H_{21}$	0	148.46	154.41	154.86	176.31	196.57	215.58	233.54	250.50	266.46	281.57

Table 8

Compound	TEMPERATURE °K									
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Heat of Formation ΔH°_f — kcal** / mole										
CH_3–S–CH_3	—20.37	—24.12	—24.40	—24.42	—25.47	—26.34	—27.04	—27.58	—27.97	—28.25	—28.39
CH_3–S–C_2H_5	—24.30	—29.26	—29.64	—29.67	—31.05	—32.20	—33.12	—33.81	—34.31	—34.63	—34.76
CH_3–S–C_3H_7	—28.31	—34.47	—34.93	—34.97	—36.69	—38.08	—39.21	—40.04	—40.64	—41.02	—41.17
CH_3–S–C_4H_9	—32.12	—39.48	—40.03	—40.06	—42.10	—43.76	—45.08	—46.06	—46.76	—47.18	—47.36
CH_3–S–C_5H_{11}	—35.69	—44.24	—44.88	—44.92	—47.28	—49.19	—50.71	—51.84	—52.64	—53.11	—53.30
CH_3–S–C_6H_{13}	—39.37	—49.12	—49.84	—49.89	—52.51	—54.74	—56.46	—57.73	—58.61	—59.15	—59.36
CH_3–S–C_7H_{15}	—43.01	—53.97	—54.77	—54.82	—57.76	—59.25	—62.17	—63.58	—64.56	—65.15	—65.38
CH_3–S–C_8H_{17}	—46.66	—58.82	—59.70	—59.75	—63.01	—64.75	—67.88	—69.44	—70.51	—71.15	—71.40
CH_3–S–C_9H_{19}	—50.30	—63.68	—64.62	—64.69	—68.27	—69.26	—73.58	—75.29	—76.45	—77.16	—77.42
CH_3–S–$C_{10}H_{21}$	—53.94	—68.53	—69.55	—69.52	—73.52	—74.77	—79.29	—81.15	—82.40	—83.16	—83.44

** Reaction: (n + 1) C (graph) + (n + 2) H_2 (g) + ½ S_2 (g) → CH_3–S–C_nH_{2n+1} (g)

Table 9

Compound	TEMPERATURE °K									
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Free Enthalpy of Formation ΔG°_f — kcal** / mole										
CH_3–S–CH_3	—20.37	—9.95	—8.64	—8.54	—3.09	2.60	8.46	14.42	20.44	26.52	32.60
CH_3–S–C_2H_5	—24.30	—8.71	—6.81	—6.67	1.21	9.42	17.82	26.37	35.00	43.68	52.40
CH_3–S–C_3H_7	—28.31	—7.63	—5.20	—5.03	5.40	15.87	26.75	37.81	48.96	60.19	71.45
CH_3–S–C_4H_9	—32.12	—6.39	—3.39	—3.17	9.45	22.54	35.91	49.49	63.17	76.95	90.75
CH_3–S–C_5H_{11}	—35.69	—4.91	—1.34	—1.07	13.91	29.44	45.30	61.40	77.61	93.95	110.30
CH_3–S–C_6H_{13}	—39.37	—3.51	0.64	0.94	18.30	36.28	54.65	73.27	92.03	110.85	129.72
CH_3–S–C_7H_{15}	—43.01	—2.10	2.65	2.99	22.73	43.16	64.03	85.18	106.18	127.86	149.29
CH_3–S–C_8H_{17}	—46.66	—0.69	4.66	5.05	27.16	50.04	73.41	97.09	120.93	144.87	168.85
CH_3–S–C_9H_{19}	—50.30	0.72	6.67	7.10	31.59	56.93	82.80	109.00	135.38	161.88	188.42
CH_3–S–$C_{10}H_{21}$	—53.94	2.13	8.68	9.15	36.02	63.81	92.18	120.91	149.83	178.89	207.98

** Reaction: (n + 1) C (graph) + (n + 2) H_2 (g) + ½ S_2 (g) → CH_3–S–C_nH_{2n+1} (g)

Table 9 we calculated for the contribution of a —S— group to the free enthalpy of formation (see correlation presented in Part 26[9] of this series)

$$\Delta G^\circ_{f\text{-}S\text{-}} = -4.588 + 1.306 \times 10^{-2} \times T \quad (300 \ldots 600\ ^\circ K)$$

$$\Delta G^\circ_{f\text{-}S\text{-}} = -3.724 + 1.162 \times 10^{-2} \times T \quad (600 \ldots 1000\ ^\circ K)$$

In order to retain internal consistency with the correlation given previously[9] the constants in these formulae are presented to more significant figures than is warranted by the accuracy of the correlation.

With the help of these formulas and the correlation given before[9] the free enthalpies of the gaseous n-2-thia alkanes, starting from methyl-n-propylsulfide can be calculated with an average deviation of $\pm$ 0.3 $\frac{\text{kcal}}{\text{mole}}$ and a max. deviation of $\pm 0.8 \frac{\text{kcal}}{\text{mole}}$.

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KEY WORDS FOR INDEXING

Enthalpy
Entropy
Heat Capacity
Petrochemicals
Thermodynamics

Size Exchanger Nozzle by Nomograph

This nomograph permits rapid sizing of nozzles for Class R and Class C heat exchangers in accordance with the latest edition of TEMA standards

Jer Ru Maa, Villanova University
Villanova, Pa.

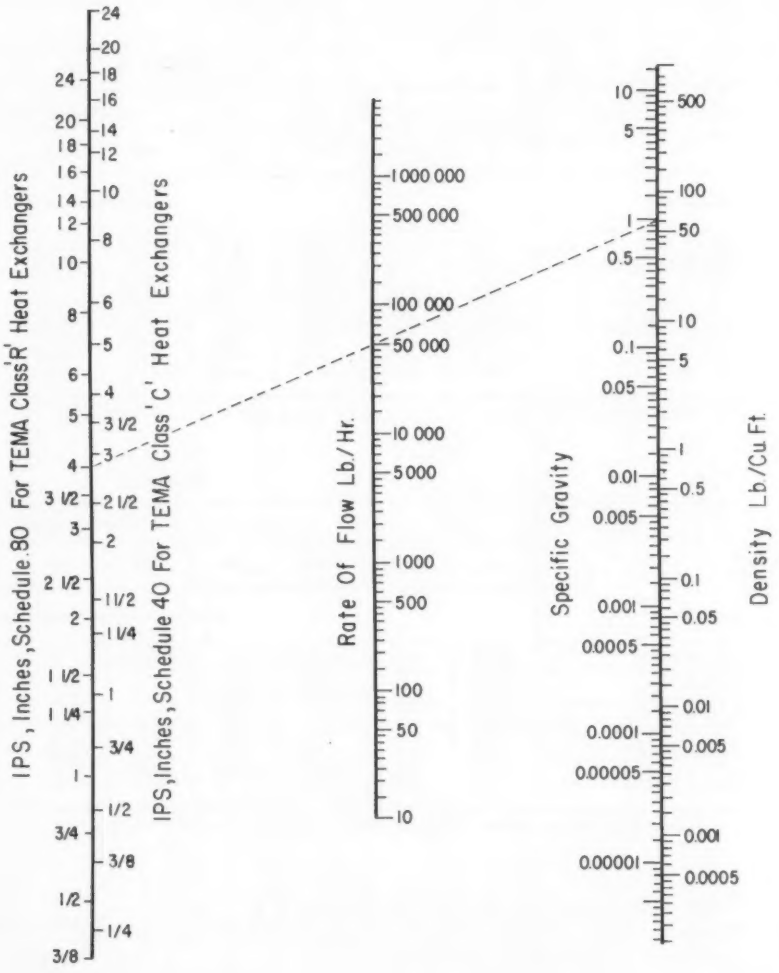
SIZES OF STEEL PIPE used as nozzles on tubular heat exchangers can be determined directly from the flow rate and fluid density by using this nomograph. The nomograph is based on the following data from the fourth edition of "Standards of Tubular Exchanger Manufacturers' Association" (TEMA):

$\rho V^2 = 500$ TEMA R-4.61
$\rho V^2 = 1500$ TEMA C-4.61

Where, V is the linear velocity of the fluid in feet per second and ρ is its density in pounds per cubic foot.

For services involving non-corrosive, non-abrasive, single phase flow having nozzles larger than that determined from this nomograph, protection against impingement may not be required.

Example—For water flowing at 50,000 pounds per hour, the nozzle size is 4 inch. Sch. 80 pipe. Note that the nomograph is for shell inlet nozzles without impingement plate.


IPS, Inches, Schedule 80 For TEMA Class 'R' Heat Exchangers
IPS, Inches, Schedule 40 For TEMA Class 'C' Heat Exchangers
Rate Of Flow Lb./Hr.
Specific Gravity
Density Lb./Cu Ft.

STANDARDS OF TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION

Mechanical Standards TEMA Class "R" Heat Exchangers
R-4 BAFFLES AND SUPPORT PLATES
R-4.6 Impingement Baffles
R-4.61 Impingement Protection Requirements

For services involving non-corrosive, non-abrasive, single phase fluids having entrance line values of ρV^2 less than 500, protection against impingement may not be required. In this, V is the linear velocity of the fluid in feet per second, and ρ is its density in pounds per cubic foot. In all other cases means shall be provided to protect the tube bundle at entrance against impinging fluids.

Mechanical Standards TEMA Class "C" Heat Exchangers
C-4 BAFFLES AND SUPPORT PLATES
C-4.6 Impingement Baffles
C-4.61 Impingement Protection Requirements

For services involving non-corrosive, non-abrasive, single phase fluids having entrance line values of ρV^2 less than 1500, protection against impingement may not be required. In this, V is the linear velocity of the fluid in feet per second, and ρ is its density in pounds per cubic foot. In all other cases means shall be provided to protect the tube bundle at entrance against impinging fluids.

About the Author

Jer Ru Maa is a graduate student in chemical engineering at Villanova University and expects to continue his graduate studies at Pennsylvania State University. Before coming to the United States in 1959, he was assistant engineer with the Union Industrial Research Institute in Taiwan, China. Mr. Maa received a BS in chemical engineering from Cheng Kung University in Taiwan in 1954 and an MS in chemical engineering from Villanova University in 1960.

Find Diesel Properties by Nomograph

Quickly estimate the cetane number, viscosity and calorific value from the gravity and mid boiling point

George E. Mapstone
Johannesburg, South Africa

THE FIRST ROUTINE TEST usually carried out on an intermediate distillate fraction is the gravity and ASTM distillation. These data can be used to estimate other important fuel properties such as the calorific value, viscosity and cetane number. These properties are of prime interest if the fraction is to be used or processed for use as a diesel fuel.

The accompanying nomographs were designed by the method of Lo-Ho[1] from data presented by Tilton et al[2] and Blackwood and Cloud[3] to allow ready estimation of the cetane number, viscosity and calorific value from the gravity and mid boiling point.

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Figure 2 on next Page

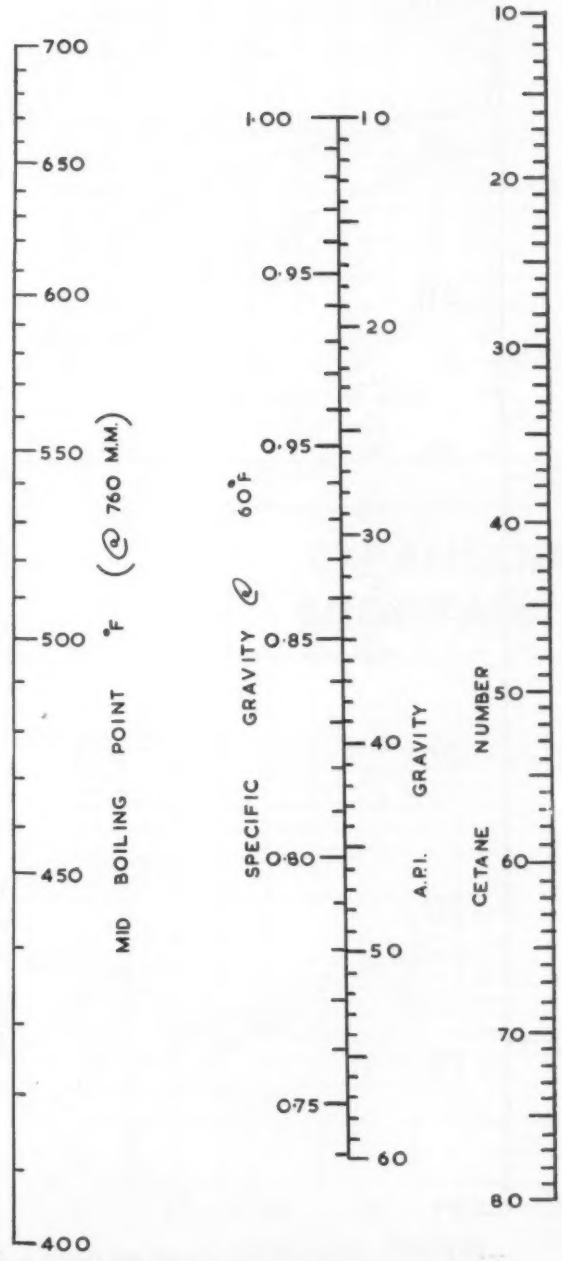


FIGURE 1—Align mid boiling point and gravity for diesel cetane number.

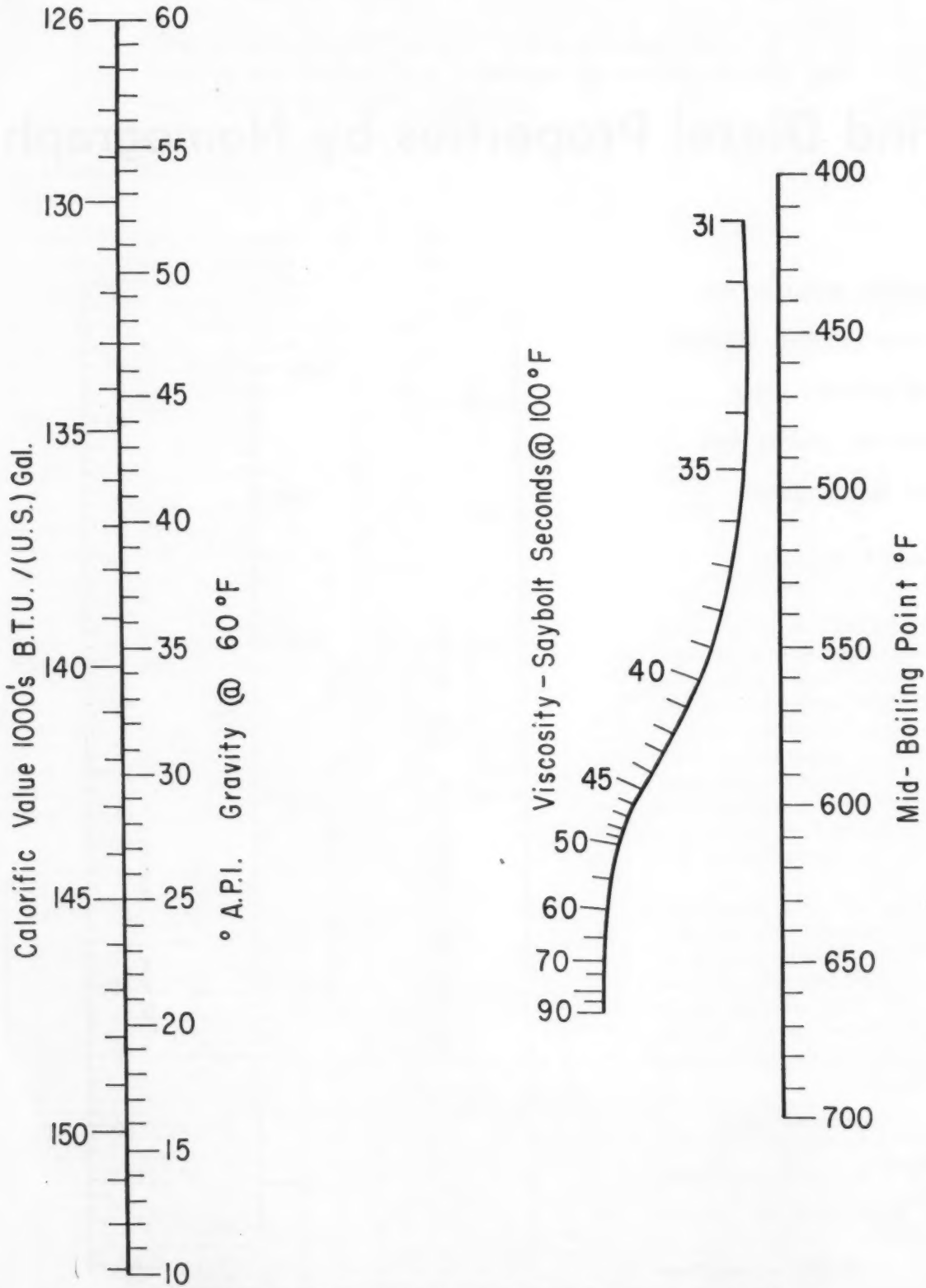


FIGURE 2—From mid boiling point and gravity pick off viscosity and calorific value.

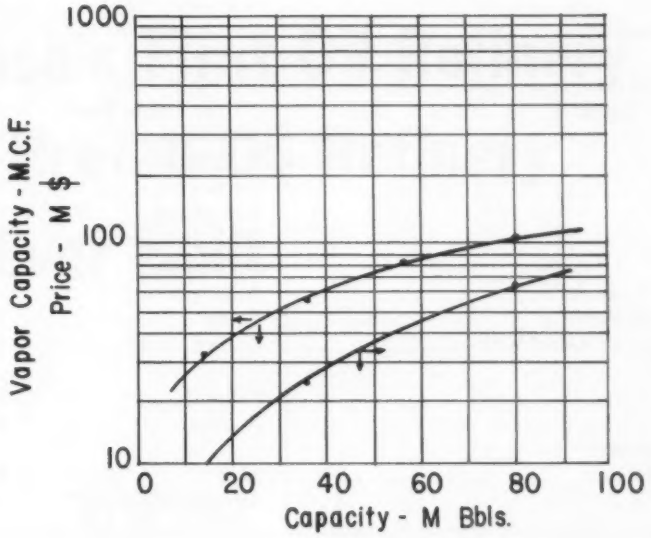
Equipment Cost Data File

DIAPHRAGM TANKS

N. H. Prater, Mobay Chemical Co., Pittsburgh, Pa.
John Mylo, The Chemstrand Corp., Decatur, Ala.

The cost of diaphragm type storage tanks delivered and erected on customers proposed foundation can be estimated from this chart. The capacity shown is the total liquid volume that can be stored in barrels. The vapor capacity shown is the total volume available for conservation of expanded on displaced vapors. Included in the total cost are the following basic accessories:

Manholes
Relief Valves
Roof Supports
Vapor Chamber
Diaphragm Support
Balancing rings and counterweights
Guide Devices
Spiral Stairway
Ladder
Flanged connections for the usual appurtenances



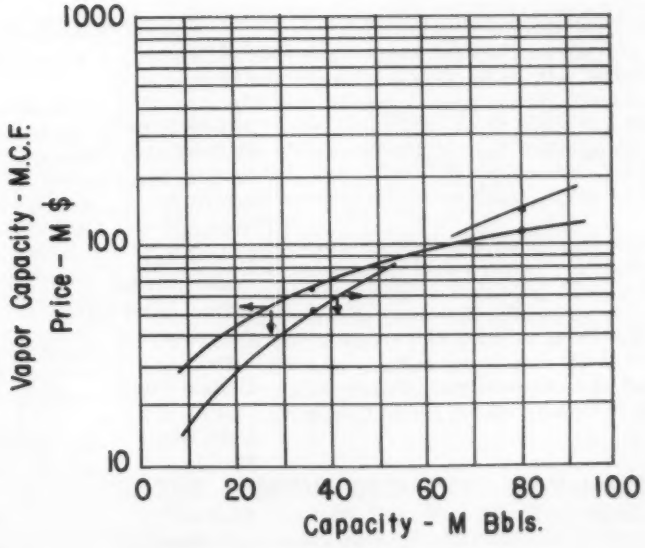
Equipment Cost Data File

EXPANSION ROOF TANKS

In the storage of volatile liquids such as gasoline and other valuable products, special tanks are used to conserve vapors and prevent breathing and filling losses. These include the movable roof or vapor lift type tanks. Under normal conditions the lifter roof will rest on the roof supports as in the conventional cone roof tank. As the volume of vapor in the tank increases the roof will rise. A 5-foot lift is the minimum practical lift. Higher lifts are normally employed in manifolded tank systems.

Basic cost of expansion or lifter roof tanks with a 5-foot lift can be estimated from this chart. Prices are based on a delivered and erected tank on customers foundation. Actual costs of specific tanks are on the reverse side.

Key Words for Indexing
Costs Tanks



DIAPHRAGM TANKS

The diaphragm tank employs a gas-tight diaphragm attached to the inside periphery of a cylindrical steel housing. The bag is clamped to a circular ring fixed inside the vapor chamber. The vapor chamber is mounted on the roof of the product tank. It functions as a breathing device that accommodates the expanding and contracting vapors developed in tanks storing volatile products. The diaphragm tank prices are from firm vendor quotations. Specific design details for this type storage tank are listed on the reverse page.

Date:	3-20-60	3-20-60	3-20-60
M/S Index:	237	237	237
Mfr.:	.....	.....	.....
Capacity:	14,000 Barrels	36,000 Barrels	80,000 Barrels
Vapor Capacity:	10,000 Cubic Feet	25,000 Cubic Feet	65,000 Cubic Feet
Size:	50′ Diameter	80′ Diameter	120′ Diameter
	40′ High	40′ High	40′ High
Type:	Vertical	Vertical	Vertical
	Cylindrical	Cylindrical	Cylindrical
	With Internal Fabric	With Internal Fabric	With Internal Fabric
	Diaphragm	Diaphragm	Diaphragm
Tank Pressure:	Atmosphere	Atmosphere	Atmosphere
Type of Roof:	Fixed	Fixed	Fixed
Material of Construction:	Carbon Steel	Carbon Steel	Carbon Steel
Weight:	.....	.....	.....
Price:	$32,000	$56,500	$104,000
F.O.B.:	Florida	Florida	Florida
Price/Pound:	.....	.....	.....
Price/Barrel:	$2.29	$1.57	$1.30
Code:	API Standard	API Standard	API Standard

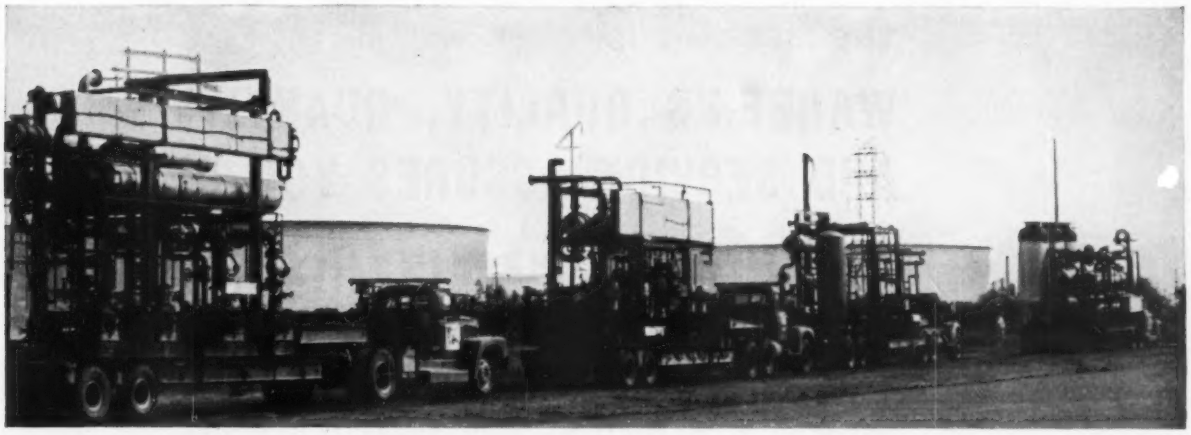
EXPANSION ROOF TANKS

Expansion or lifter roof tanks provide full liquid storage capacity as well as a variable vapor space to store the vapors generated in the tank or in other tanks to which they are connected. These costs for expansion roof tanks having a 5-foot lift are from firm vendors quotations.

Date:	3-20-60	3-20-60	3-20-60
M/S Index:	237	237	237
Mfr.:	.....	.....	.....
Capacity:	14,000 Barrels	36,000 Barrels	80,000 Barrels
Vapor Capacity:	20,000 Cubic Feet	50,000 Cubic Feet	150,000 Cubic Feet
Size:	50-foot Diameter	80-foot Diameter	120-foot Diameter
	40′ High	40′ High	40′ High
Type:	Vertical	Vertical	Vertical
	Cylindrical	Cylindrical	Cylindrical
	With Internal	With Internal	With Internal
	Fabric Diaphragm	Fabric Diaphragm	Fabric Diaphragm
Tank Pressure:	Atmosphere	Atmosphere	Atmosphere
Type of Roof:	Fixed	Fixed	Fixed
Material of Construction:	Carbon Steel	Carbon Steel	Carbon Steel
Weight:	.....	.....	.....
Price:	$36,500	$63,000	$121,000
F.O.B.:	Florida	Florida	Florida
Price/Pound:	.....	.....	.....
Price/Barrel:	$2.61	$1.75	$1.51
Code:	API Standard	API Standard	API Standard

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

Central America's First Oil Refinery Is Largest Prefab Oil Refinery Ever Built



The largest skid mounted oil refinery ever constructed has just been installed near Puerto Matias de Galvez, Guatemala, for the Breaux Bridge Oil Refining Company, Inc.

This 4,000 barrel-per-day refinery was designed by the Houston office of The Lummus Company to meet an unusual set of conditions in the rain forests of Central America.

Because of a shortage of labor in the area, Lummus found it impossible to follow its usual practice of employing local craftsmen. In addition, an average of 190 inches of rainfall per year pointed to excessive difficulties in on-site construction. These conditions, coupled with the relatively small size of the process units, suggested the use of prefabricated refinery units that could be built in the United States and shipped to Guatemala.

The refinery consists of atmospheric distillation, naphtha desulphurizing, and catalytic reforming processing units, together with the necessary supporting offsite facilities.

Lummus evolved the plan of mounting pumps, compressors, exchangers, accumulators, etc., for the various process units on steel skids. Large vertical process towers, due to shipping limitations, could not be skid-mounted.

The plant was carefully designed so that when assembled and completed it could be easily operated and maintained. The design resulted in the use of seven process equipment skids—four are pictured above—plus two compressor skids.

Prefabricating and prepackaging techniques were also used in the design and transporting of heaters, boilers, electric generation equipment, water system pumps, and even refinery personnel housing.

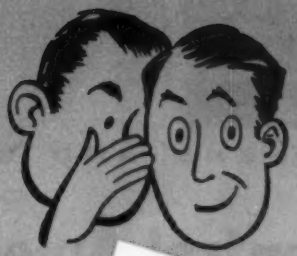
Lummus felt that this design concept had many advantages. Design, procurement, and construction schedules could be overlapped to a much greater extent than usual, resulting in a shorter completion schedule and many economies. Also, better quality control could be maintained. Construction was completed in 10 months after clearing of the dense jungle jobsite. It is estimated that the same refinery, constructed by conventional means, would have taken about 15% longer, and because of the necessity of importing craftsmen for the distant jobsite, it would have cost about 10% more.

The portable plant technique is one that Lummus knows well. Ten years ago, the company built a similar, but smaller, skid-mounted portable refinery for the U. S. Navy. Lummus has also designed and constructed transportable pilot plants for the Wulff acetylene process, a refinery pilot plant, an atomic reactor test loop, and a nitrous oxide unit among others.

If you have a construction problem which might be solved through this technique, Lummus would be pleased to discuss it with you.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, New York, Houston, Washington, D. C., Montreal, London, Paris, The Hague, Madrid; Engineering Development Center: Newark, N. J.

WHETHER WE WHISPER . . .



OR

SHOUT

THE MESSAGE IS:

WARREN'S QUALITY, QUANTITY AND SERVICE ASSURES YOU OF

DEPENDABLE DELIVERIES OF NATURAL GASOLINE

(whatever the volume, whatever the grade)

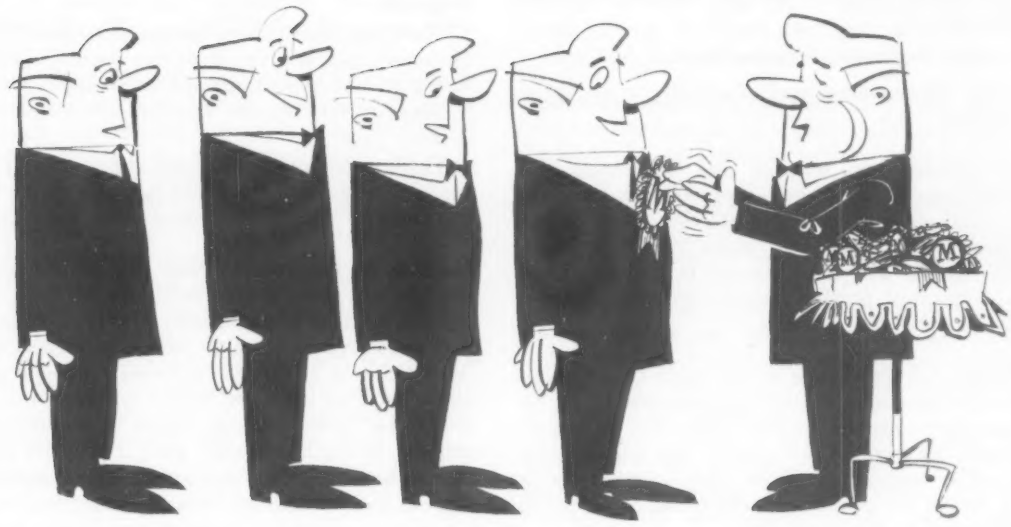
WHEN, WHERE and the WAY *you* want it!

WARREN

PETROLEUM CORPORATION

TULSA, OKLAHOMA

EXPORT TERMINALS: CORPUS CHRISTI, PORT ARTHUR, BAYTOWN, TEXAS CITY AND WARRENGAS, HOUSTON, TEXAS, SAN PEDRO, CALIF.



Chances Are—You'll Be a Manager

If you aren't already a manager or supervisor, you probably will be before long. It's almost a statistical certainty, and here's why

Dr. Keith Davis
Arizona State University, Tempe, Arizona

Your chances of some day being on the management team (if you aren't already) are better than you ever dreamed. This is almost a statical certainty, provided you continue working to develop the personal and intellectual qualifications required of a leader in modern industry. "Well," you say, "what of all this talk about increased automation, reduction of the work force (which would seem to mean a need for fewer managers), more management 'decisions' by computers, leveling off in productivity, etc." Okay, let's examine the facts.

A Large Order. To set our discussion in perspective, let's look at the reasons for our growing management shortage. Then we will project managerial needs for the total economy in 1975, and finally apply that projection to the petroleum and chemical industry specifically. Just to whet your curiosity, I suggest that the nation must develop 8,606,500 new managers by 1975, including 215,754 for the petroleum and chemical industries! That's a large order.

With all the effort we have put into management development the last ten years, it seems we would catch up. If anything, we are falling behind. (Remember several years ago when some people thought management development was only a fad?) Here are some of the reasons for this continuing shortage.

1. Our labor force is growing; hence new managers must be developed to manage the new workers. More on this later.

2. With our new technology and worldwide business and social developments, industry is becoming more dynamic. The petrochemical industry is a good example. Firms which made a slow start in petrochemicals are now feeling the effects. There is worldwide research evi-

dence that growing, dynamic industries require a greater *proportion* of managers in their work force. The proportion of managers also increases as

(a) a business increases in size,

(b) its market structure becomes broader and more complicated,

(c) capital investment becomes heavier.

All three developments apply especially to the petroleum industry.[1]

3. In industry more scientific and engineering men are moving into management. These men lack knowhow in both management theory and practice. Their college work rarely allowed room for "'management" or "business" courses, yet they must *manage* in business. Thus, the employer must provide more-than-normal training to make up for these deficiences.

4. In agrarian society and in very small organizations doing simple functions, enough management to get by could usually be learned by experience. But in today's complicated big business, only rarely can management be learned by experience. Even then, it often comes near the end of a man's career, rather than in his prime when managerial talent is needed.

Today we want to accelerate a man's learning of management so he can start managing while young and vigorous. We cannot wait for experience-learning with its turtle speed.

The conclusion: management is becoming a skilled professional activity learned by diligent study, under guidance.

5. As our international operations grow, we are "exporting" more managerial talent to foreign subsidiaries and associate companies. Each manager "exported" creates a need for producing more managerial talent internally in our U.S. company.

6. Our managerial force today is older than normal because of World War II and other factors. A number of firms are expecting to retire, during the next ten years, more than one-half their higher management group. It is certain that retirement in our managerial group will be extra large in the next decade. We must develop their replacements *before* retirement occurs.

7. Also, we just have not done much educationally in the past to prepare talented men for managerial leadership. We talk about gaining better managers for the future through more liberal arts education, but *that's what we have had the last 50 years.*

Business has been run largely by liberal-arts-educated managers. That was about the only kind of education available when they went to college. And many feel we could have had better managers in the past. For the future, we are not likely to get better ones by keeping the old educational standards.

New Concept. What we need is a new concept of management education—one which provides a liberally or technically educated man but which also teaches him the theory and art of professional management, and which includes carefully planned, long-range development, within the company. This kind of man will contribute to public welfare by helping society produce (and distribute) *more* with more efficiency rather than developing new welfare programs to use current production.

There are other reasons for our management shortage. However the ones given show that our national shortage may get worse. And, there are factors applying especially to the petroleum industry to accelerate its need for managers.

There is one other point. Since the managerial shortage will be general there will be more effort by other industries to recruit your good men away from you.

Looking at the Future. Now let's project nationwide management development needs for all types of managers in all types of organizations by 1975. Estimates are that we shall have some 20 million more persons in the labor force by 1975.[2] A significant economic study recently declared industrial society different from what it used to be. Today workers cannot be productive in our complex society unless their work is properly guided by competent managers.[3] So, we must train a proportion of these 20 million new workers as managers.

Using a ratio of 12.5 percent managers in a labor force,[4] we see that 2.4 million *new* managers must be trained to service this new labor force. (The term "manager" as used here applies to all who supervise people (i.e., plan, organize, direct, and appraise their work) in any type of organization. It excludes key staff people who do not supervise but are sometimes said to be part of "management.")

Increased Production. If our present trend toward industrialization continues, even more than 2.5 million managers must be trained, because advanced technology requires an increase in the proportion of managers in the labor force. For example, more than two thirds of 50 companies recently studied increased their proportion of managers during the 1947-1955 period. The average increase was 32 percent for excutives and 52 percent for staff assistants to executives. (From 10 to 15 percent managers is an increase of 50 percent.) Some firms were so shocked by this change in their management-labor ratio that they had their figures[5] rechecked.

If our management-labor ratio should increase from 12.5 to 14 percent in 1975,[6] we would have to train an additional 300,000 managers for the new labor force plus 990,000 more mangers for the existing labor force.

Further, some trained for management will fail or will choose some other work. An allowance of 10 percent for this "shrinkage," means that an additional 280,000 managers must be trained for new labor force replacement. This means a grand total of 3,080,000 managers needed for the new labor force.

Since those who will comprise the work force in 1975 are already alive, this managerial need is certain to come to pass, barring some great human catastrophe. Even if these estimates are 500,000 too high, our management development needs for the *new* labor force will still be bigger than our present meager efforts can meet.

Labor-Management Ratio. Now let's look at our existing civilian labor force, about 66 million.[7] Using our same proportion of 12.5 percent managers, about 8,250,000 of our labor force actually manage. Considering that their average work life as managers is less than 30 years, we will have to train replacements for about one half of them by 1975, or 4,125,000 replacement managers.

Since our managerial group today is topheavy with age, we will probably have to train even more. Applying the increased management-labor ratio from 12.5 to 14 percent and the 10 percent shrinkage figure, we need to train 1,401,500 additional replacements, making a grand total of 5,526,500 replacement managers. Added to the 3,080,000 managers for the new labor force, this is a total managerial development need by 1975 of 8,606,500 persons! If that seems out of reason just remember we are talking about all levels of managers in all types of organizations.

Even this astronomical figure does not include the re-training and development training of existing managers during the next 15 years. Certainly our management development efforts must include them.

The College Picture. In this day of large figures, a development need of 8,606,500 may not seem large. But if we look at it in relation to the job our colleges are doing, we soon realize how big it is. For example, business schools in the United States graduated 57,000 persons and engineering schools 35,000 in 1957-58. At this rate, in 15 years they would graduate only 1,380,000 as against the eight million managers needed. Even double this graduation rate would offer only 2,760,000 persons from business and engineering schools.

The Industry Picture. Turning now to the needs of the petroleum and chemical industries, a recent report shows they employed 1,098,000 persons.[8] Since this is a dynamic industrial group, let's assume it grows to add its share of the new labor force—303,000 employes by 1975. It is assumed that labor decreases from automation will be offset by other factors, such as previously mentioned. Using computations applied earlier, the industry's management development needs by 1975 are 215,754, or more than 15,000 annually for *new* managers. Existing managers also must be trained for promotion and/or to keep them up to date.

About Computers. One word of caution. Some analysts have forecast that computers will do decision making by 1975, and almost wipe out our middle managers. Certainly computers will be "deciding" many of our standardized, quantifiable problems. However even if they made all our decisions, managers still must perform major functions other than decision making. If the computer does some of their work, then they will have more time better to perform other functions such as motivation, leadership, and community relations.

It is unlikely that computers will replace large groups of managers—so we had better start developing managers to fill our coming stortage,

There is a saying, "He doesn't know his own strength." If this is true occasionally, it also is likely that the reverse is true, "We don't know our own weaknesses!" Good management results from long, long range planning and high investment in developing people. It is, therefore, a capital investment just like a new catalytic cracking unit or a new petrochemical plant. But unlike these, the results are much less predictable, the planning is more long range, and the "construction" (development) takes longer.

Managers Are Made. Managers are made, not born. And they cannot be developed in the short span of a month, a year, or two years. Rather, the development is quite complicated. It takes years to bring each executive up to normal managerial competence. After that, there is a regular need for re-education to meet changed conditions, and further development to prepare for higher positions.

Hence, management development becomes an unending requirement in modern industrial society. There is no escape from the need—no other route to company efficiency.

Since management development is slow, we must start now to prepare to meet our needs in the 1970's. If we wait until this decade is upon us, it is to late.

About the Author

Davis

Dr. Keith Davis is a professor and chairman of the Management Department, Arizona State University, and for 10 years has been management consultant to a number of companies, including Texaco Inc., Firestone, and Allied Laboratories. Holder of a M.B.A. degree in management from the University of Texas and Ph.D. degree in management from Ohio State University, he has taught at Indiana, Ohio State, and Texas universities. Dr. Davis has written more than 40 professonal articles and three books on human relations and management problems. A Fellow of the Academy of Management, he is a member of numerous professional societies and associations and has taught the following management development programs: Colorado Executive Program, Southwest Executive Program, UCLA Executive Program, Ohio University Executive Program, and Georgia Executive Management Seminar. He has also conducted programs for the Executive's Association of Havana and the Chilean Management Association.

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[1] For a concise explanation of these points see Frederick Harbison and Charles A. Myers, *Management in the Industrial World*, New York; McGraw-Hill Book Company, 1959, pp. 21-27.

[2] *Business Week*, March 8, 1958, p. 134.

[3] Harbison and Myers, *op. cit.*, p. 27.

[4] This figure is derived from census figures and studies of management-labor ratios in organizations.

[5] "Our Growing Executive Population," *The Management Review*, September, 1959, pp. 34-36.

[6] For example, in 1952 one study of manufacturing firms showed that managers were 13.6 percent of the work force at that time. See Robert D. Loken and Winfield C. J. Thake, "How Many Managers Are There?" *Current Economic Comment*, November, 1952, pp. 18-27.

[7] This 1958 figure is chosen to be consistent with the date of the estimate of new workers by 1975, discussed earlier. Employed civilian labor force on June 30, 1960, was 68,579,000. See U.S. Department of Labor, *Employment and Earnings*, July, 1960, p. 1.

[8] U.S. Department of Commerce, *U.S. Income and Output*, 1958, p. 211.

Key Words for Indexing

Management Personnel Supervision

What You Should Know About Arbitration

The word "arbitration" is becoming increasingly common on the American industrial scene. But do you know what it is and how it works? You will after reading this article

American Arbitration Association

Voluntary arbitration of controversies arising out of or relating to the terms of collective bargaining agreements is accepted almost unanimously by labor and management. But despite widespread use of this procedure, and possibly due to its fast growth, often parties mistake arbitration for other methods of dispute settlement, such as conciliation and compromise.

Arbitration is a tool of industrial relations. Like other tools, it has limitations as well as uses. In the hands of an expert, it produces good results, but when abused, or made to do things for which it was never intended, the outcome may be disappointing. That is why all participants in the process—labor union officials, employers, personnel executives, attorneys, businessmen generally and the arbitrators themselves—have an equal stake in orderly, efficient and constructive arbitration procedure.

What Is Arbitration? *Arbitration is the reference of a dispute, by voluntary agreement of the parties, to an impartial person for determination on the basis of evidence and argument presented by such parties, who agree in advance to accept the decision of the arbitrator as final and binding.*

Thus, the arbitration process begins where other methods of dispute settlement leave off. In referring a matter to arbitration parties are presumed to have explored every avenue of negotiation and compromise. As a last resort, they call upon an impartial person for a *judicial* decision and agree to abide by the result.

TWO FIELDS OF ARBITRATION

In general, labor-management arbitration is divided into two fields: contract-negotiation disputes, sometimes called arbitration of *interests;* and contract-interpretation disputes, sometimes called arbitration of *rights.* The latter is much more prevalent.

Contract-Negotiation Disputes. All authorities agree that it is best for unions and companies to establish terms and conditions of employment by direct negotiation and bargaining. This is the way the overwhelming majority of the 125,000 collective bargaining agreements in the United States are concluded. There are occasions, however, when parties are unable to agree on contract terms. In such cases, rather than risk a deadlock which might interfere with production, they sometimes refer disputed items to arbitration, putting the agreed-upon matters into effect immediately.

Such situations come about not only when new contracts must be negotiated but at wage reopening dates. Some contracts provide in advance for arbitration of such wage-reopening disputes. But in any case, parties who want to arbitrate differences over contract terms may use arbitration machinery by executing *submission agreements.* (See Glossary, Page 280.)

Contract-Interpretation Disputes. Contract-interpretation disputes, usually called *grievances,* make up most matters brought to arbitration. Before reference to arbitration, such controversies usually go through several

steps of *grievance procedure* set forth in contracts, during which each side tries to convince the other that his interpretation and application of the contract to the given situation is the correct one. It is also during grievance procedure that compromises are attempted. Failing settlement during these negotiation steps, well over 90 percent of all collective bargaining contracts provide for impartial arbitration. When time is critical, parties sometimes mutually agree to by-pass earlier steps and bring a controversy directly to arbitration.

THE AGREEMENT TO ARBITRATE

Labor-management disputes are brought to arbitration in one of two ways, either by a *submission agreement* which describes an *existing* controversy which *both* parties want settled by an impartial person, or by a *demand for arbitration* filed by *either* party to a contract, provided that contract has an arbitration clause.

Of the two forms which the agreement to arbitrate may take, the arbitration clause is by far the most common. Surveys indicate that approximately 95 percent of the collective bargaining contracts in effect contain future dispute clauses. The specific forms these clauses take, however, are varied. Often, companies and unions have found that their history of bargaining and their collective bargaining relationship justifies a general agreement to arbitrate, with few limitations or restrictions.

On the other hand, there may be situations in which parties prefer to limit arbitration to specified types of grievances. In either case, the construction of the arbitration clause is very important to both parties. It represents a voluntary and binding agreement to settle differences in impartial arbitration rather than in any other way.

Advantages of the Arbitration Clause. A future dispute arbitration clause leaves nothing to chance. When a controversy arises, the parties may be in no mood to agree and it is sometimes difficult to get *both* parties to submit to the procedures of arbitration. But when they are subject to a clause, arbitration may be started without delay by either party.

The agreement to arbitrate, if it does not refer to established rules and procedures, does not, by itself, answer all questions. Among the problems that remain are:

- How shall arbitrators be appointed?
- When and where shall hearings take place? And who will make these decisions if the parties cannot agree?
- Shall the arbitration board consist of one or of three neutral arbitrators?
- If a tri-partite board is preferred (see Glossary of Terms), what shall the remedy be if the two party-appointed arbitrators cannot agree upon an impartial member of the board?
- What about representation by legal counsel? Shall witnesses be sworn?
- How shall requests for adjournments be handled, May briefs be filed?
- How are hearings closed and under what conditions may they be reopened?
- When will the award be rendered? To whom delivered?
- How much should the arbitrator be paid?

All these, and many other procedural questions, may be important for prompt and effective arbitration. It would obviously be impossible for parties to anticipate them all and spell out the answers in the collective bargaining agreement. But an effective, though simple, solution is found in an arbitration clause which, by referring to established rules such as those of the American Arbitration Association, at once answers the basic WHAT, HOW, WHEN, WHERE and WHO of arbitration listed under "A Good Arbitration Clause in 50 Words."

Other Questions to be Answered. Parties may also want other questions answered. They may want to be sure that certain steps precede arbitration. They may want to spell out which types of issues are arbitrable and which are to be excluded from the arbitration process. In that case, they may vary the language of the arbitration clause to suit their needs.

But in any case, reference to the Voluntary Labor Arbitration Rules of AAA provides a quick answer to most questions and a remedy for the failure of either party to perform certain acts, called "conditions precedent." Without this, arbitration might be frustrated.

A GOOD ARBITRATION CLAUSE IN FIFTY WORDS

Any dispute, claim or grievance arising out of or relating to the interpretation or the application of this agreement shall be submitted to arbitration under the Voluntary Labor Arbitration Rules of the American Arbitration Association. The parties further agree to accept the arbitrator's award as final and binding upon them.

This clause, or any other clause referring to established rules of AAA, answers the questions below:

WHAT—
—is to be arbitrated?
—are the duties and obligations of each party?

HOW—
—is arbitration initiated?
—are arbitrators appointed and vacancies filled?
—are time and place for hearings fixed?
—are hearings opened? Closed? Reopened?
—are costs controlled?

WHEN—
—are arbitrators appointed?

—must hearings begin?
—must the award be rendered?

WHERE—
—are notice, documents and correspondence to be sent?
—shall hearings be held?
—is the award to be delivered?

WHO—
—administers the arbitration?
—keeps the records and makes technical preparations?
—gives notice of hearings and other matters?
—appoints the arbitrators if the parties cannot agree?
—fills vacancies on arbitration boards when necessary?
—grants adjournments?

THE ARBITRATION PROCESS BEGINS

By Submission Agreement. Either party to the controversy may file a submission agreement with an office of the Association, provided it is signed by *both* parties. A submission agreement must include a brief statement of the matter in dispute and of the relief sought. If the parties have named an arbitrator, AAA will contact him and the parties, arranging a time and place for hearings. If an arbitrator has not been named in the submission agreement, he will be selected in accordance with AAA Rules, described later.

By Demand for Arbitration. Where parties are subject to an arbitration clause in a contract, either party may initiate arbitration by serving notice on the other party, with a copy of the Demand forwarded to AAA. Notice of intention to arbitrate should be given in a manner and within the time limits described in the collective bargaining agreement. Contracts usually require that notice of arbitration be given within a certain period of time after the final step of grievance procedure. Failure to observe these time limits may result in loss of the right to arbitrate that controversy.

The demand for arbitration should include a brief statement of the issue to be arbitrated and the relief sought, and it should be signed by the complaining party. The arbitrator's authority will be limited to resolving only those disputes authorized by the arbitration clause and to answer, within the framework of the contract, only those questions put before him. So care should be taken to avoid "new" issues which have not gone through grievance procedure and which have not been considered before. The statement of the issue and of the relief sought in the Demand for Arbitration is usually the one set forth in the written statement of the grievance.

The AAA supplies Demand and Submission forms on request. But in the absence of forms, parties may initiate arbitration through ordinary letters. In any case, whether the parties use forms or correspondence, the following information is essential.

Check-list for Initiating Arbitration

1. Names and addresses of *both* parties involved in the Submission or the Demand for Arbitration.
2. Date of the collective bargaining agreement and the full text of the arbitration clause.
3. The issue to be arbitrated, specifically and concisely stated, with an indication of the relief sought.
4. All dates involved in the grievance.
5. Names of employees involved, together with their positions or job classifications, where necessary.
6. The written signature of the union or company officer filing the Demand for Arbitration or the Submission.

On receiving the Demand for Arbitration, AAA will invite the "responding" party to file an answering statement within seven days. If no answer is filed within this time, it is assumed that the claim is denied.

The Demand and the reply are read by the arbitrator at the beginning of the hearing. These two documents guide him in receiving and giving weight to testimony, and they form the framework within which he will make his award. The statement of claim and the reply should therefore indicate precisely what the arbitrator is asked to decide. Parties should not argue their claims in the Demand or Answering Statement, but merely state the controversy as clearly as possible.

HOW THE ARBITRATOR IS SELECTED

AAA maintains a National Panel of Arbitrators whose members, after having been nominated (usually by prominent citizens of their communities), have been selected for their experience, competence and impartiality. The candidate for enrollment in the Panel is asked to submit a statement of his professional qualifications and references as to his acceptability by both labor and management.

This data is verified by a special AAA Committee on Panels which makes the decision on the prospective arbitrator's eligibility. Once accepted as a member of the National Panel of Arbitrators, his name is sent out on lists from which parties may select arbitrators in particular cases. It is also from this Panel that the Association makes administrative appointments.

In their agreement to arbitrate, parties may provide for any method of selecting an arbitrator. Methods currently in use vary widely. Unions and companies are advised to consider the system they adopt carefully, as the speed and efficiency of arbitration may be affected.

AAA's System for Selecting the Arbitrator. Unless parties have indicated any other method, AAA invokes the following simple, effective system.

1. On receiving the Demand for Arbitration or Submission Agreement, the Tribunal Clerk (a staff member of the Association) acknowledges receipt thereof and sends *each* party a copy of a specially prepared list of proposed arbitrators. In drawing up this list, he is guided by the statement of the nature of the dispute.
2. Parties are allowed seven days to study the list, cross off any names objected to, and number the remaining names in the order of preference. Where parties want more information about a proposed

arbitrator, such information is gladly given on request.

3. Where parties are unable to find a mutual choice on a list, the Association will submit additional lists, at the request of both parties.
4. If, despite all efforts to arrive at a mutual choice, parties cannot agree upon an arbitrator, the Association will make an administrative appointment. But in no case will an arbitrator whose name was crossed out by either party be so appointed.

Collective bargaining agreements often provide for tri-partite boards of arbitration (see Glossary of Terms) without setting time limits for appointment of the party-appointed arbitrators. In that case, the AAA system will be applied so as to give force and effect to the wishes of the parties. Thus, unless parties have indicated otherwise, each side is given seven days to name his arbitrator.

Wishes of Parties Observed. By the same token, where the collective bargaining agreement provides for selection of the impartial member of the board of arbitration "by the American Arbitration Association," the lists will be sent to the parties. On the other hand, where parties prefer the two party-appointed arbitrators to choose the third, lists will be sent to the arbitrators directly, with the same time limits in effect.

Many states require that arbitrators take an oath to faithfully hear and examine the matters in controversy and render a just award to the best of their understanding. In the absence of such laws, AAA Rules provide for the oath, unless waived by the parties.

At all times, arbitrators are expected to observe the standards which that oath and the Code of Ethics for Arbitrators impose. In signing an AAA Acceptance of Appointment form, they are required to certify that they have no interest, personal or otherwise, in the outcome.

PREPARING FOR THE ARBITRATION HEARING

By the time a case reaches arbitration, parties have generally spent many weeks, if not months, in discussing the grievance. In this process, they have become familiar with all the complications. The problem then remains of communicating this understanding of the facts to the arbitrator. He usually knows nothing about the dispute until the hearing begins. Effective presentation of these facts and arguments should begin with thorough *preparation* for arbitration. The following steps are suggested:

1. Study the original statement of the grievance and review its history through every step of the grievance machinery.
2. Examine carefully the initiating papers (Submission or Demand) to determine the authority of the arbitrator. It might be found, for instance, that while the original grievance contains many elements, the arbitrator, under the contract, is restricted to resolving only certain aspects.
3. Review the collective bargaining agreement from beginning to end. Often, clauses which at first glance seem to be unrelated to the grievance will be found to have some bearing on it.
4. Assemble all documents and papers you will need at the hearing. Where feasible, make photostatic copies for the arbitrator and the other party. If some of the documents you need are in the possession of the other party, ask that they be brought to the arbitration. Under some arbitration laws, the arbitrator has authority to subpoena documents and witnesses if they cannot be made available in any other way.
5. If you think it will be necessary for the arbitrator to visit the plant for on-the-spot investigation, make plans in advance. The arbitrator will have to be accompanied by representatives of *both* parties; it is also preferable that the Tribunal Clerk be present.
6. Interview all witnesses. Make certain they understand the whole case and particularly the importance of their own testimony within it.
7. Make a written summary of what each witness will prove. This will be useful as a check-list at the hearing, to make certain nothing is overlooked.
8. Study the case from the other side's point of view. Be prepared to answer the opposing evidence and arguments.
9. Discuss your outline of the case with others in your organization. A fresh viewpoint will often disclose weak spots or previously overlooked details.
10. Read as many articles and published awards as you can on the general subject matter in dispute. While awards by other arbitrators for other cases have no precedent value, they may help clarify the thinking of parties and arbitrators alike. The AAA reports labor arbitration awards released by parties in a monthly publication, *Summary of Labor Arbitration Awards.*

THE ARBITRATION HEARING

The date for the hearing is fixed by the arbitrator after discussion with the Tribunal Clerk who has consulted the parties on this question. As on all other administrative matters, the function of the Tribunal Clerk is to handle details and arrangements. The Tribunal Clerk also makes arrangements in advance when either party wants a stenographic record of hearings.

After introduction of the arbitrator and swearing-in ceremonies, the customary order of proceedings is as follows:

1. Opening statement by the initiating party, followed by a similar statement by the other side.
2. Presentation of evidence, witnesses and arguments by the initiating party.
3. Cross examination by the other party.
4. Presentation of evidence, witnesses and arguments by the defending party.

5. Cross examination by the initiating party.
6. Summation by both parties, usually following the same order as in the opening statements.

This is the *customary* order. The arbitrator may vary this order, either on his own initiative or at the request of a party. In any case, the order in which the facts are presented does not imply that the "burden of proof" is more on one side than the other, for *both* parties must try to convince the arbitrator of the justice of their positions.

HOW TO PRESENT A CASE IN ARBITRATION

The Opening Statement. The opening statement should be prepared very carefully, because it lays the groundwork for the testimony of witnesses. It helps the arbitrator understand the relevance of oral and written evidence. The statement, although brief, should describe the controversy clearly, show what is sought to be proved, and indicate the relief sought.

The question of the right remedy, if the arbitrator should find that a violation of the agreement did take place, deserves careful attention at the outset. A request for relief should be specific. This does not necessarily mean that if back pay is demanded, for instance, it is essential for the complaining party to have computed an exact dollar-and-cents amount. But it *does* mean that the arbitrator's authority to grant such relief under the contract should not be in doubt.

Because of the importance of the opening statement, some parties prefer to present it to the arbitrator in writing, with a copy given to the other side. They believe that it may be advantageous to make the initial statement a matter of permanent record. It is recommended, however, that the opening statement be made orally even when prepared in written form. An oral presentation adds emphasis and gives persuasive force to one's position.

While opening statements are being made, parties are frequently able to stipulate facts about the contract and the circumstances which gave rise to the grievance. Giving the arbitrator all the uncontested facts early in the hearing saves time throughout, thereby reducing costs.

Presenting Documents. Documentary evidence is often an essential part of a labor arbitration case. Most important is the collective bargaining agreement itself, or the sections that have some bearing on the grievance. Documentary evidence may also include such material as correspondence, official minutes of contract negotiation meetings, personnel records, medical reports and wage data.

Every piece of documentary evidence should be properly identified, with its authenticity established. This material should be physically presented to the arbitrator (with a copy made available to the other side), but an oral explanation of the significance of each document should not be omitted.

In many instances, key words, phrases and sections of written documents may be underlined or otherwise marked to focus the arbitrator's attention on the essential features of the case. Properly presented, documentary evidence can be most persuasive. It merits more than casual handling.

Examining Witnesses. Each party should depend on the *direct examination* of his own witnesses for presentation of facts. After a witness is identified and qualified as an authority on the facts to which he will testify, he should be permitted to tell his story largely without interruption.

Although leading questions may be permitted in arbitration, testimony is more effective when the witness relates facts in his own language and from his own knowledge. This does not mean, however, that questions from counsel may not be useful in emphasizing points already made or in returning a witness to the main line of his testimony.

Cross Examining Witnesses. Every witness is subject to cross examination. Among the purposes of such cross examination are: disclosure of facts the witnesses may not have related in direct testimony; correction of misstatements; placing of facts in their true perspective; reconciling apparent contradictions; and attacking the reliability and credibility of witnesses.

In planning cross examination, the objective should be kept in mind. Each witness may therefore be approached in a different manner, and there may be occasions when cross examination will be waived.

Maintaining the Right Tone. The atmosphere of the hearing often reflects the relationship between the parties. The chief purpose of the arbitration hearing is the determination of the grievance. But a collateral purpose of improving that relationship may also be achieved by skillful and friendly conduct of the parties. Thus, a better general understanding between the parties may be a by-product of the arbitration. To this end, the parties should enter the hearing room with the intention to be objective and dignified. The arbitration hearing should be informal enough for effective communication, but without loss of that basic sense of order essential in every forum adjudication.

The hearing is no place for emotional outbursts, long speeches with only vague relevancy to the issue, for bitter, caustic remarks, or personal invective. Apart from their long-run adverse effect on the basic relationship between the parties, such immoderate tactics are unlikely to impress or persuade an arbitrator. Similarly, over-technical and over-legalistic approaches are not helpful.

A party has every right to object to evidence he considers irrelevant, for the arbitrator should not be burdened with a mass of material that has little or no bearing on the issue. But objections made merely for the sake of objecting often have an adverse effect, for they may give the arbitrator the impression that one simply fears to have the other side heard.

The Summary. Before the arbitrator closes the hearing, he will give both sides equal time for a closing statement. This is the time to summarize the factual situation and emphasize again the issue and the decision the arbitrator is asked to make.

As arbitration is a somewhat informal proceeding, arguments may be permitted to some extent during all phases of the hearing. There may be times, however, when the arbitrator will require parties to concentrate on presenting evidence and put off all arguments until the summary. In either event, all arguments should be stated fully.

Finally, as this will be the last chance to convince the arbitrator, the summary is the time to refute all arguments of the other side.

Post-Hearing Procedure. After both sides have had equal opportunity to present all their evidence, the arbitrator declares the hearing closed. Under AAA Rules, he has 30 days from that time within which to render his award, unless the collective bargaining agreement requires some other time limit.

If parties want to file written post-hearing briefs, transcripts of records or other data, time limits are set and hearings remain open until those documents are received. As usual, exchange of post-hearing material takes place through the Tribunal Clerk; *the parties do not communicate directly with the arbitrator except when both sides are present.* The Association will see that both briefs are transmitted to the arbitrator and that an interchange takes place between parties at the same time.

How To Reopen Hearings. When parties jointly agree to add certain data after a hearing is closed, they may arrange to do so by written stipulation filed with the Association. The arbitrator will then accept the new material and take it under advisement.

In the event new evidence is discovered, or when a situation arises that appears to require explanation, parties should not attempt to communicate directly with the arbitrator. They should request the arbitrator, *through the Association,* to reopen proceedings and conduct an additional hearing or arrange for presentation of evidence through other means. The arbitrator may also reopen hearings on his own initiative when he deems it necessary.

Under the AAA procedure all contact between the parties and the arbitrator must be channeled through the Association. This eliminates the possibility of suspicion that one side may have offered arguments or evidence which the other had no opportunity to rebut.

Common Errors in Arbitration

1. Using arbitration and arbitration costs as a harassing technique.
2. Over-emphasis of the grievance by the union or exaggeration of an employee's fault by management.
3. Reliance on a minimum of facts and a maximum of arguments.
4. Concealing essential facts; distorting the truth.
5. Holding back books, records and other supporting documents.
6. Tying up proceedings with legal technicalities.
7. Introducing witnesses who have not been properly instructed on demeanor and on the place of their testimony in the entire case.
8. Withholding full cooperation from the arbitrator.
9. Disregarding the ordinary rules of courtesy and decorum.
10. Becoming involved in arguments with the other side. The time to try to convince the other party is before arbitration, during grievance processing. At the arbitration hearing, all efforts should be concentrated on convincing the arbitrator.

THE AWARD

The award is the decision of the arbitrator upon the matters submitted to him under the arbitration agreement. Its purpose is to dispose, finally and conclusively, of the controversy.

The award must be made within the limits of the arbitration agreement, must rule on each claim submitted, and be definite and final. It may be accompanied by an Opinion discussing the evidence and setting forth the reasoning of the arbitrator.

> The power of the arbitrator ends with the making of the award. An award may not be changed by the arbitrator, once it is made, *unless the parties mutually agree to reopen the proceding and to restore the power of the arbitrator.*

When the parties do agree to request the arbitrator to reopen a proceeding in order to obtain a clarification or interpretation of a disputed ruling, the agreement to reopen must be in writing and must set forth precisely the question submitted. Such agreement is filed with the Association which then proceeds to make the necessary arrangements with the arbitrator.

Awards by Tri-Partite Boards. The frequent use of tripartite boards of arbitration sometimes creates special problems. Under law, the award must be supported by at least a majority. The difficulty is that the two party-appointed arbitrators may regard themselves as advocates of their sides, rather than impartial adjudicators, which may make it difficult for the impartial arbitrator to get the support of one of the others for a majority award. Parties often resolve this difficulty by empowering the third arbitrator to render a decision without the concurrence of the others. This may be done either in arbitration clauses or, in the event of deadlock, by later stipulation of the parties.

> *When this is done, the third arbitrator is in a better position to rule on the issues as he sees them without having to compromise his position for the sake of a majority award.*

THE COSTS OF ARBITRATION

There are several items of expense that should receive consideration in any arbitration proceeding. *First,* there is the expense of preparation and presentation of the case; *second,* the expense of the stenographic report of the testimony (if desired); *third,* the arbitrator's fee; and *fourth,* the administrative expense.

The *first* expense is clearly within the control of each party. In complex cases parties sometimes require the help of outside experts such as time-study engineers or economists. But this added expense is seldom necessary in the average grievance arbitration.

The *second* item of expense, the stenographic record, is a much debated item. As a general rule, arbitrators take their own notes and do not need stenographic records. In complicated cases, stenographic records are frequently found helpful not only by arbitrators, but also by parties in preparation of written briefs. When a party wants a stenographic record, AAA arranges to have a court reporter present at hearings. The party or parties ordering a record will be billed directly by the stenographer. It is therefore up to them to instruct him with regard to copies and billing.

The Arbitrator's Fee. The *third* item of expense is the arbitrator's fee. The usual charge made by an arbitrator is $100 per day of hearing and per day used for preparation of the award. Fees differ, however, and it is AAA's policy and practice to have the rate of compensation agreed upon in advance, and through AAA. Parties may then know before the arbitrator is appointed the costs that they will incur.

The *fourth* item of expense, administrative cost, includes the administrative fee paid to AAA—$30.00 from each party, and includes all the administrative work in connection with the case as well as the first hearing. An additional $30.00 is charged for each subsequent hearing. The parties are required to pay any special expense, such as travel and hotel bills of the arbitrator and tribunal clerk, long-distance telephone calls and telegrams, or any other unusual administrative expense. AAA makes every effort to keep such expenses at a minimum.

CONCLUSION

Arbitration is the most practical means ever devised for resolving disputes which unions and companies are unable to settle by direct negotiation. It is the application to industrial relations of the American democratic concept of "due process."

But the significance of arbitration is not only in its immediate advantages. The atmosphere of dispute settlement may have a profound effect upon the way labor and management get along in their day-to-day relations. That is why arbitration is more than a useful tool for coping with existing problems; it is also a moral force, encouraging a spirit of co-operation which often makes it possible for companies and unions to resolve difficulties without having to go to arbitration at all.

The American Arbitration Association. The American Arbitration Association is a private, non-profit organization founded in 1926 to foster the study of arbitration, to perfect the techniques of this method of dispute settlement under law and to administer arbitration in accordance with the agreement of parties. Membership rolls include companies, labor unions, trade associations, civic groups, foundations and organizations of all kinds as well as individuals who believe in arbitration.

AAA is today the most important single center of information, education and research on arbitration. To bring about the widest possible understanding, hundreds of educational programs are presented every year at universities and law schools and organizations of every description. AAA's educational program includes publication of a quarterly magazine, a quarterly arbitration law reporting service, a monthly news bulletin for members, specialized pamphlets covering every field of arbitration, and outlines for teaching labor-management arbitration and arbitration law courses.

The original text of this article was prepared by the late J. Noble Braden, executive vice president of the American Arbitration Association. It has been expanded and revised by Joseph S. Murphy, vice president of education, and Morris Stone, editorial director.

Key Words For Indexing

Employes
Labor
Management
Personnel
Supervision
Unions

GLOSSARY OF TERMS

ARBITRATION. Arbitration is the reference of a dispute by voluntary agreement of the parties to an impartial person for determination on the basis of evidence and argument presented by such parties, who agree in advance to accept the decision of the arbitrator as final and binding. Arbitration, therefore, is a judicial proceeding and different in nature from mediation, conciliation, negotiation and fact-finding.

ARBITRATION CLAUSE. An arbitration clause is a provision in a contract requiring that disputes arising out of or relating to the collective bargaining agreement be finally determined by arbitration.

GRIEVANCE PROCEDURE. Grievance procedure of a union contract is an orderly way to resolve disputes by successive steps, usually beginning with negotiations between union stewards and foremen and ending with meetings between top union and company officials.

SUBMISSION AGREEMENT. A submission agreement is a jointly signed document stating the nature of the dispute and affirming the parties' intention to arbitrate and to abide by the award.

DEMAND FOR ARBITRATION. A demand for arbitration is a formal request made by one party to the other for arbitration of a particular dispute under the arbitration clause of a contract.

ANSWERING STATEMENT. An answering statement is the respondent's reply to a demand for arbitration.

ARBITRATION HEARING. The formal meeting at which each party presents its exhibits, witnesses and arguments to the arbitrator.

TRI-PARTITE BOARD. A board consisting of a representative of each party and an impartial arbitrator.

AWARD. An award is the decision which the arbitrator renders after taking testimony and hearing arguments from both sides. The award is usually accompanied by an opinion in which the arbitrator explains how he came to his conclusions.

You Can Benefit From Committee Work

Regardless of objectives, size, or degree of responsibility given committees in your company, you'll probably have a chance to serve. Here's how doing so can increase your job effectiveness and prestige

Auren Uris, Research Institute of America

"Committees are a waste of time." Many an executive viewing the inability of a group to get anywhere has voiced that opinion. But before jumping on the "committee-go-home" bandwagon, several considerations may help form a more constructive view.

Start with the fact that, like it or not, *committees are here to stay.* Companies often need ideas from groups before making a decision or taking action. The implication here is that what's wrong with committees is not that they aren't useful but that their purposes are not acted on by group members.

Even more important than this consideration, is a personal one: becoming a committee member can create a unique opportunity for you. The committe can be a show case—a situation in which you can "grandstand" in an acceptable way. You can display your unique capabilities for the benefit of your colleagues and supervisor.

A Chance to Expand. Serving on a committee lets you prove yourself outside the framework of your regular activity. Even for the man who has not felt constrained in his job, committee activity affords a chance for enriching experience. This comes from challenging assignments and new relationships with colleagues and others.

However, to gain committee-work benefits, you must be aware of both opportunities and pitfalls. Each company has its own approach to the committee setup. In some organizations scarcely a day goes by without a group being formed. But in other firms, committees seldom come into being.

Further, committees may be set up for a variety of purposes:

- **To investigate**
- **To develop**
- **To plan**
- **To decide**
- **To take action.**

Some companies may form committees for only one of these purposes, others take advantage of two or more.

Among individual executives you find much variation. The executives who find committees effective tend to create them freely. Those who take the dim view set up a committee only when existing staffs or persons are incapable of doing the job.

Seven Ways to Win. Regardless of objectives, size or degree of responsibility given committees in your company, from time to time you probably will have a chance to be on one. The following seven guide-points can help you get specific benefits from your participation, and minimize possible drawbacks.

1 *Try to get on "do" Committees, Avoid the dead-enders*

Some experts may say there is no clear-cut line between "do" and "do-nothing" groups. "It all depends," they will say, "on the members of the committee. A group of dynamic men add up to a committee that gets things done. A group of apathetic ones make for a committee that never gets off the ground."

There is some truth to this. But probe deeper and you find that certain committees, *because of their objectives,* are practically predestined to get nowhere. Here is an example:

The president of a small independent refinery confides to his assistant, "Some day we're going to have to move

to larger quarters. Might as well set up a group of people to look into the possibility of a new plant location."

A sharp executive in that company would realize that because of the company's financial situation, such a move, though desirable, could not take place in less than five years. Members of the "New-Plant Committee" would probably become involved in an investigation that could not result in any firm conclusions or action. Another pertinent fact: When the company *was* able to seriously consider a move, both the available properties and company needs might have completely changed—making the investigations useless.

On the other hand, the "do" committees are marked by the immediacy and importance of their objectives. A group set up to develop an urgently needed product to meet competition; a group to consider the best possible process to use in a new unit; a group to discuss merger possibilities with another company, are examples of committees not likely to get soft from lack of exercise.

2 *Volunteer for assignments that carry benefits for you*

In some cases you select the committee to serve on or, being on the committee, have a chance to pick a particular assignment. With this choice in mind, there are three selections advantageous to you:

- **The area in which you want to develop.** Let's say you are a process engineer, and you've been wanting to learn more about your company's safety activities. As assignment that would make it possible to investigate the safety function would clearly pay off for you.

- **The area of the company's future growth.** Assume your company is considering diversifying. That could mean anything from going in for products that parallel the present ones, to investigating completely new products or different types of operation.

In whatever direction the change may lie, activity in a committee that would help you familiarize yourself with the future interests of your company would obviously give you a desirable edge.

- **Area of your best capabilities.** Sometimes your wisest course may be to take assignments that play up your strongest technical or executive skills.

If, for example, you are a good organizer and there is a need for someone to take over this function in a committee, your work will obviously show up to good advantage. Interestingly enough, the same skill that might be accepted as a matter of course in your regular job may well bring you wide recognition in this new context.

3 *Consider your fellow-committeemen your self-development "audience"*

"How is my boss going to know if I do a good job?" a young engineer lamented. "Everything we do is confined by the four walls of our meeting room." That complaint overlooks the fact that fellow members of your committee generally form a powerful sounding board.

Every executive is familiar with the potency of informal communication channels. Word-of-mouth reports over the lunch table can score for you as certainly as headlines in the company newspaper.

The word *does* get around. But don't let that simple statement blind you to the fact: the thing that is mentioned is the significant event—the outstanding circumstance.

Informal channels will buzz when some one makes a crackerjack speech, when someone puts on a dramatic presentation, when someone's clear thinking has struck the group like a sudden revelation.

At the same time, performance need not be dramatic. You don't have to make a "grandstand play" to make an impression. Many a man has made a reputation for himself by consistent, mature, solid thinking. It is the man who speaks up and represents his viewpoint clearly and emphatically who emerges as a recognizable and impressive figure. You have probably admired the mature executive who always states his views but has no difficulty in acknowledging the validity and value of opposing ideas.

Whatever your particular *forte,* here is a chance to show your stuff. If you are quick on the draw, incisive in your thinking—good. Let these qualities become obvious to your fellow committee members. If your thinking is slow, methodical and thorough—good. Let these virtues become evident. The greatest loss is to let your light be hidden under a bushel of silence.

4 *Should you take on committee leadership?*

You have to think this one through. Leadership of the group may be up for grabs. Should you or should you not? Several factors help you decide. If the committee's objectives have particular appeal for you, it is probably advisable. There would not be much point in heading a group whose objectives had little inherent interest for you.

In some cases a realistic decision comes from the answer to these quesctions: What do I gain if the committee is successful? What do I stand to lose if it fails? The answers are seldom cut and dried. All kinds of elements must be considered:

- **Are other committee members people who will cooperate with you?**

- **Will you have the wholehearted backing of the executive under whom the committee is functioning?**

- **Do you feel your personal and professional qualifications will help you sustain your leadership effectively?**

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• **And a simple but vital point—can you spare the time?**

It is only after you have considered as many factors as possible that you can decide whether you want to head up a particular effort, or turn down the responsibility.

5 *Be sure you know how to "balance" a committee*

You may be in a position to set up a committee. Even if you are one of an appointed group, it is still important for the committee's success for members to know what it takes to have a well-rounded team.

No one has yet come up with a perfect formula. But here are some of the kinds of talent that can make the difference between success and failure:

• **The sparkplug.** Usually he is the leader or committee head, but not always. Sometimes—particularly when the committee head is one in name only—it may be his assistant or right-hand man. Function of the sparkplug is to trigger action, point the way, keep nudging for results.

• **Resources person.** Someone in the group must know where to find what is needed for the committee to function. It may be data, information, particular skills and so on. This does not mean the individual must have everything at his finger tips. But it does mean he either knows where it is, knows where to look, or can arrange to supply what's needed.

• **The idea man.** He is the one who frequently supplies answers to such questions that start off, "But what will we do if—". He will suggest a plan of action, a solution to a problem; will help develop alternatives in a decision-making situation.

• **Analyzer.** He is the man with the dissective mind. He can look past the facts to the implications. He can put 2 and 2 together and come up with a sharp, unequivocal 4. He is the one who can forsee problems before they happen—making it possible to avoid them.

• **Fault finder.** He may not be very popular but he is liable to keep you out of a lot of trouble. Precisely because of his negative approach he becomes a pre-tester of ideas. Frequently he will probe and pick flaws in a plan of action. While what he says may not be welcomed by many, it often happens that his native pessimism may help offset over-optimistic expectations. The wise committee head can find in this "No-Man" a neutralizing force that will keep unrealistic enthusiasm from running the train right off the track.

• **The detail man.** The work of many committees involves great detail. This is where people with checklist minds come into their own. The individual with the patience or talent to check through the details is often the best insurance against costly oversights, sketchy planning, going off half cocked.

• **The doer.** He is the man who will take the time and has the energy to follow up on the scheduled course of action. It's often the absence of a doer that makes a committee ineffective. Look for a man with a passion for action. He will be the one who translates talk into accomplishment.

One further point on the "balanced" committee. Don't take the above list to mean that every committee must have an individual sparkplug, resource man, and so on. One executive may have two or more of these qualities. The point is, that committee work requires the functions mentioned and they must be represented one way or another in your group.

6 *Sharpen your objectives to eliminate inaction*

Many experts say a major reason for committee weakness is that no one has bothered to clarify exactly what the group is supposed to accomplish. Vague objectives make for inaction; specific goals breed fruitful activity.

Notice the difference in the incentive value between these two objectives:

A. "The purpose of the committee shall be to look into the nature of the competition we are facing."

B. "The purpose of the committee shall be to report to the president by January 1—(a) Number and size of the companies directly in competition with our two main products, (b) Where we stand in relation to this competition as far as share of market in the past year is concerned, (c) To what extent foreign imports are affecting our sales."

"A" may get action. "B" almost surely will.

The phrase, "sharpen committee objectives" may be harder to accomplish than the simplicity of the words indicate. Often, the first and major job of a committee is to examine, clarify and spell out what its goals are.

At some point before the group starts operating, this point must be clarified. Failure to do so is bound to result in confusion, wasted effort and eventual paralysis.

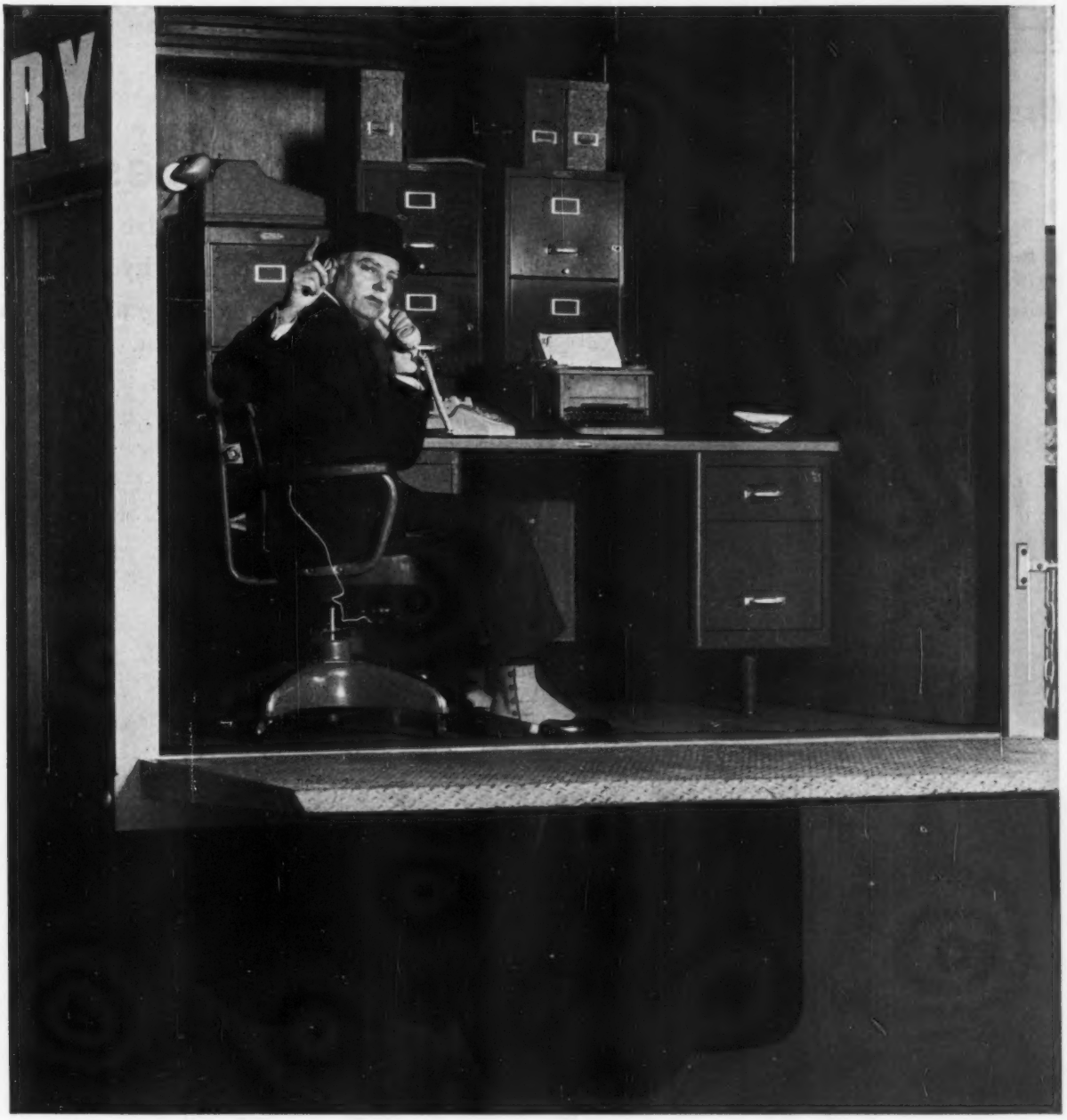
7 *Use your committee responsibility to make contacts and broaden yourself*

One virtue of committee work is that it takes you outside your regular job. You get a chance to work with colleagues you might not otherwise come in contact with, or you work with them in new relationships.

Some committee responsibilities require that you work outside the company. This can mean still broader horizons and the opportunity to gather information and experience not available within the company.

Such outside contacts may not present themselves automatically. But it often happens that once you think in terms of the question, "What contacts can I make that can better help fulfill my committee role?" You can broaden your activity horizon to the mutual gain of you and your company.

Key Words For Indexing
Management Personnel Supervision



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Nomograph helps engineer solve excess air calculations when burning hydrocarbon fuels ranging from pure hydrogen to carbon

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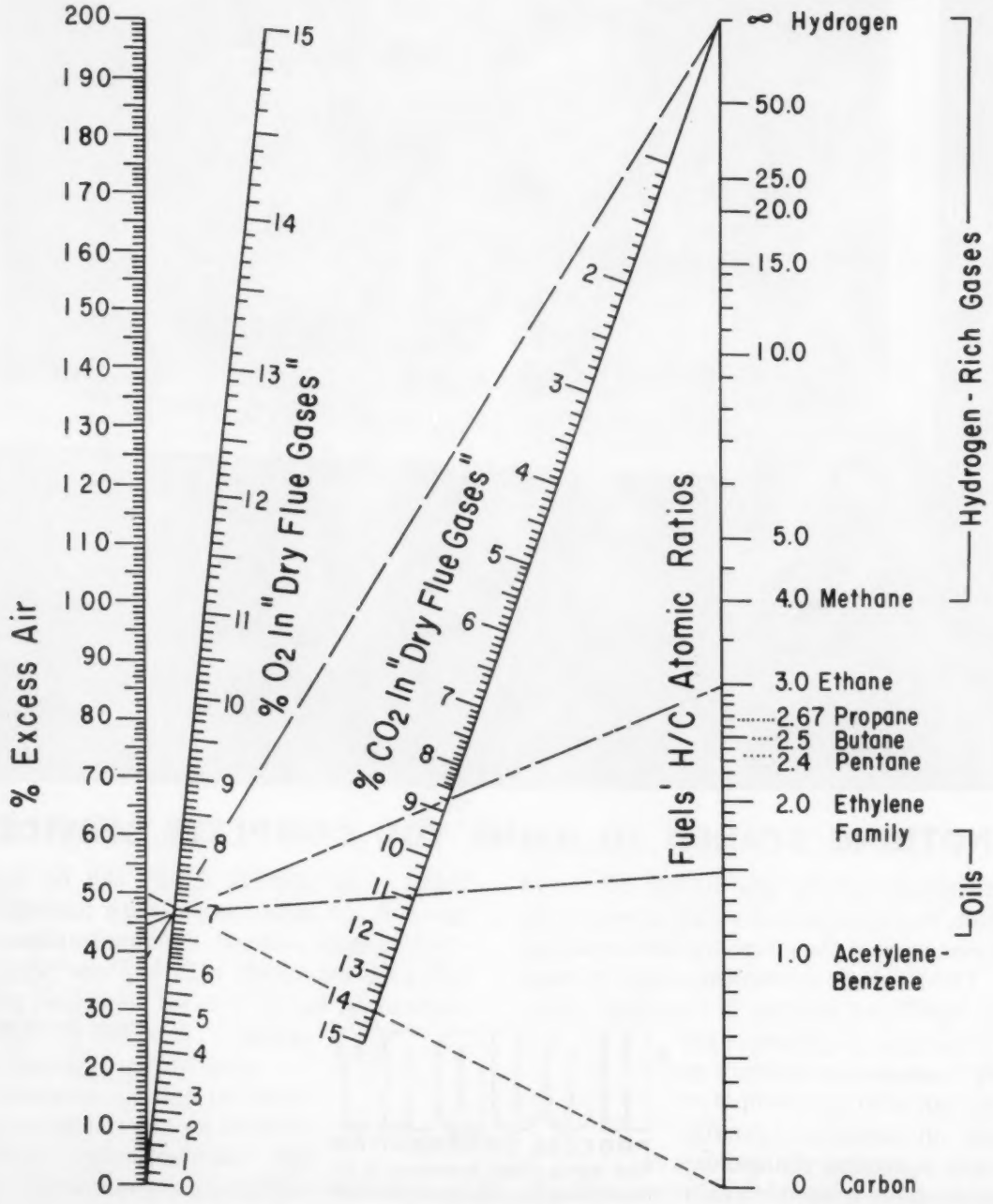

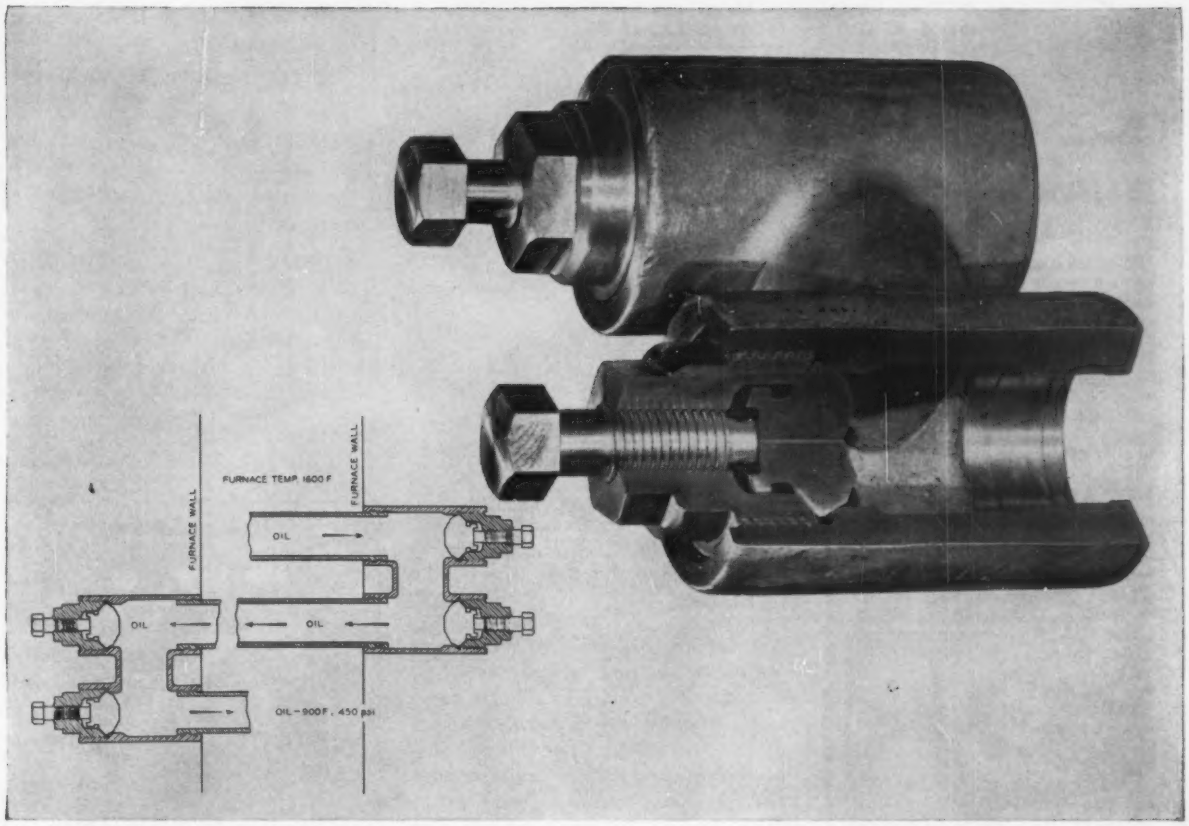

Turning Back Corrosion: these U-shaped headers reverse oil flow through cracking furnace. Cast from nickel stainless steel, they're rugged, solid, heat- and corrosion-resistant, economically produced. Holding members are easily dismantled for tube cleaning.

One-piece design helps extend life

Cast stainless steel fittings handle hot sour crudes at 450 psi...last for years!

If you've had more than your share of replacement problems with fittings exposed to corrosion, and thermal and mechanical shock, perhaps you can profit from the example of Standard Oil Company of California.

They're Getting Years of Trouble-Free Service from header bodies like the ones pictured above, cast from corrosion-resistant nickel stainless steel. The fittings are used in a petroleum-cracking furnace at the El Segundo plant. It's tough service, making high-octane gasoline from highly corrosive California crudes, which pass through these headers at 900°F and 450 psi.

To Resist This Punishing Combination, the headers were ordered integrally cast of ACI type CF-8 stainless steel, containing 8-11 per cent nickel, 18-21 per cent chromium and a maximum of 0.08 per cent carbon. Strong one-piece design minimizes danger of leakage or rupture. Generous fillets and radii eliminate troublesome crevices, make maintenance simpler. Routine coke removal is simpler, too, thanks to a combination of simple design and corrosion-resistant surfaces.

Where Can You Use Such Performance? Stainless steel castings offer exceptional advantages for many applications in petroleum processing. They often permit better designs for fittings and other components subject to *multiple* attack from corrosives, high temperatures, heavy loading, and thermal shock. For detailed information, send for Inco's new booklet "Heat Resistant Castings, Corrosion Resistant Castings... Their Properties and Applications."

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Carl G. Paulson, Director R & D group, reports

on the Hayes Nitro-Gen (TM) — low cost producer of

BLANKETING GAS

THERE ARE MANY REASONS why nitrogen's popularity is growing so fast as a blanketing gas for hydrocarbons and volatile liquids, and as a blanketing atmosphere for numerous industrial applications like food canning. Safety is a big asset of this inert, non-combustible gas. Efficiency is a deciding factor, too — nitrogen vastly improves the quality of process or product.

NEW LOW COST NITROGEN affords limitless potentials and economically, as well. With the performance-proved Nitro-Gen Generator, for example, you can produce 99.95% pure inert gas for as little as 20¢ per 1000 cu. ft. Employing Linde Molecular Sieve®*, this new Hayes generator combines stationary retort with a cyclical dryer; produces a continuous, automatic supply of gas at a very low cost; and provides a clean dry system, totally free from liquids, fumes, and corrosion problems. Best of all no highly trained specialist is required to run it.

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How to Do It . . .

The nomograph is based on the following formula:

$$e = \frac{3.76\ (\%O_2)}{100 - (\%CO_2) - 4.76\ (\%O_2)} \qquad (1)$$

$$(e + 1) = \frac{100 - [100 - (\%CO_2)]F}{4.76\ (\%CO_2)} \qquad (2)$$

$$e = \frac{(4.76 - F)\ (\%O_2)}{100 - 4.76\ (\%O_2)} \qquad (3)$$

Practical uses of the nomograph:

• Ignoring the chemical composition of the fuel, use $(\%CO_2)$ and $(\%O_2)$ Orsat-type determinations and fix the percent excess air $(= 100.e)$ and the H/C ratio of the fuel burned.

• Ignoring the exact chemical composition of the fuel, use only a $(\%O_2)$ determination (i.e. by a reliable automatic continuous-sampling-and-measuring instrument). The $(\%O_2)$ dependance on chemical fuel composition is small; therefore, the errors committed by this method are minor and "industrially neglectable." As is seen, the $(\%O_2)$ — axis is situated near the percent excess air-line.

Example:

Assume: $(\%O_2) = 7.0$.

a) Fuel burned: Gas (composition somewhere between H/C = 4 and H/C = 2).

Percent excess air = 44-46 (See nomograph).

b) Fuel burned: Oil (composition somewhere between H/C = 2 and H/C = 1).

(Percent excess air = 46-48 (See nomograph).

c) Fuel burned: Absolutely unknown, composition and H/C = ∞).

Percent excess air = 39-50! (See nomograph).

• Check your chemical Orsat-type absorbers. Assume $(\%CO_2)$ has been correctly determined because of reliable and rapid absorption by alkaline-chemicals and that the $(\%O_2)$ absorbed is under doubt.

Example: $(\%CO_2) = 8.8$; $(\%O_2) = 7.0$.

Nomenclature

e = Coefficient of excess air
$= \frac{\text{Actual air-theoretical air}}{\text{Theoretical air}}$

$(\%O_2)$ and $(\%CO_2$ = Vol/vol percent of both in "dry flue gases."

F = Coefficient depending on H/C atomic ratio $= \frac{H/C}{H/C + 4}$ i.e.,

Methane — H/C = 4/1 and F = 4/8 = 0.5.

Found by nomograph, percent excess air = 44 H/C ratio ≃ 2.95.

If the true H/C ratio is known to be between 1.0 and 2.0, as for liquid fuels the $(\%O_2)$ value is wrong and should be about 9.0 giving a percent excess air = 70 and not 44 as previously stated.

• Find the weight of each of two

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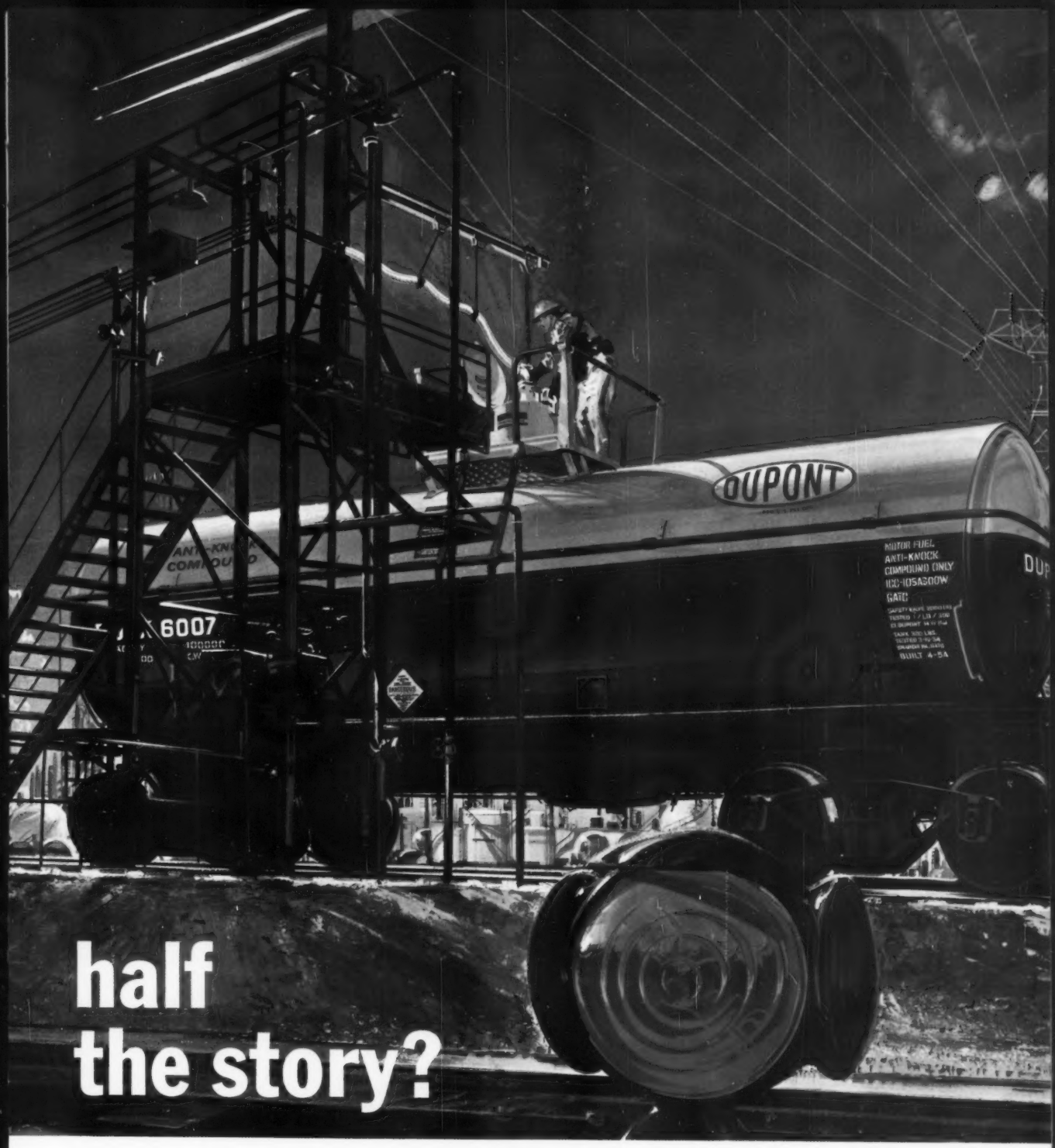
At least $10.00 will be paid for each idea accepted for "How to Do It." All you need to do is write a brief note telling about your idea, then attach a photo or sketch (if needed), and mail it to Editor, Hydrocarbon Processing & Petroleum Refiner, P. O. Box 2608, Houston.



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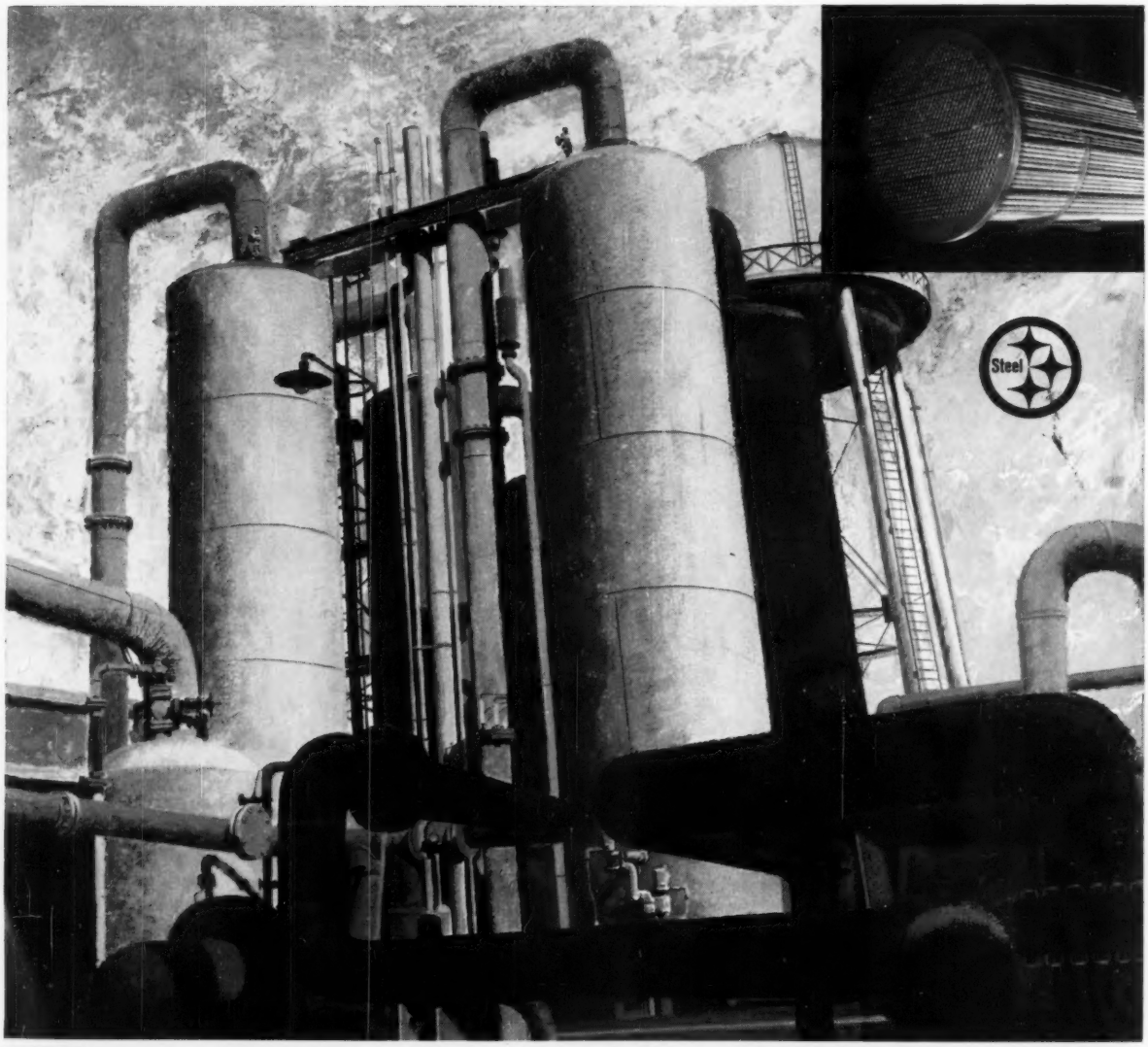

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How to Do It . . .

fuels of known chemical compositions being burned simultaneously in the same furnace.

Example: Assume Fuel "A" — H/C = 2.2 (Gas).

Assume Fuel "B" — H/C = 1.5 (Oil).

The analysis of the flue gases gave the following results:

$(\%CO_2) = 9.5$; $(\%O_2) = 7.7$.

Percent excess air = 54 (By nomograph).

H/C ratio = 1.98 (By nomograph.)

$A + B = 100$

$2.2A + 1.5B = 1.98 \times 100$

"A" = 68.6% wt/wt

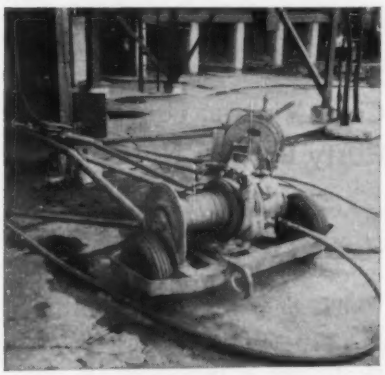
"B" = 31.4% wt/wt.

• Additional advantage of the nomograph. Complete H/C ratio range from zero to infinity which enlarges the uses of this chart for those refineries burning hydrogen-rich gases or carbon-rich solid fuels.

Note: The basic assumption made: CO present in the "flue gases" is negligible.

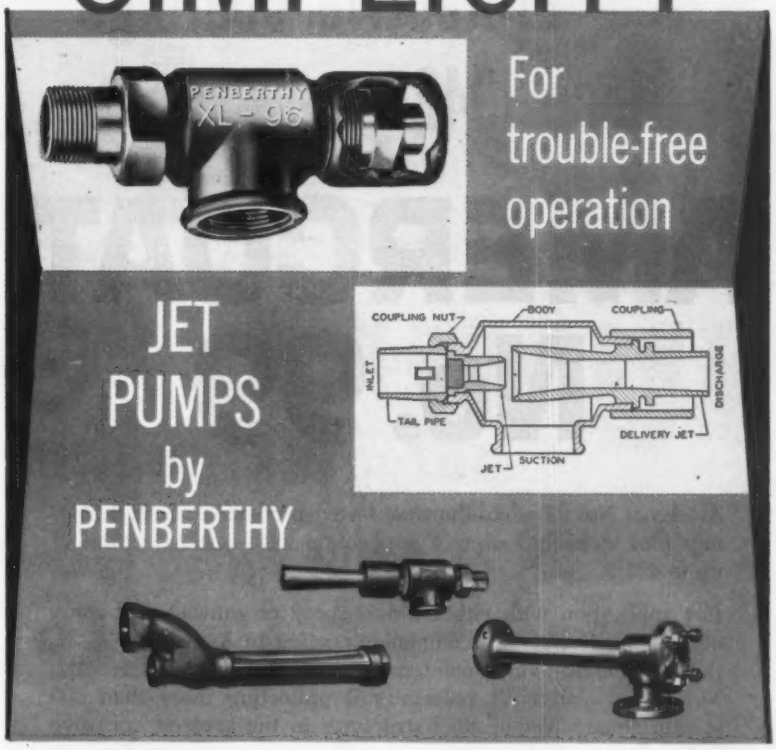
Tongue on Air Hoists Simplifies Tie Down

Where air hoists are used as prime movers in a refinery, elaborate means must usually be made to tie them down so that they can be spotted at a convenient place for the work. Glen Ralston, assistant mechanical superintendent, Continental Oil Co. refinery in Westlake, La., simply placed



tongues on the wheel-mounted air hoists to move them from place to

SIMPLICITY



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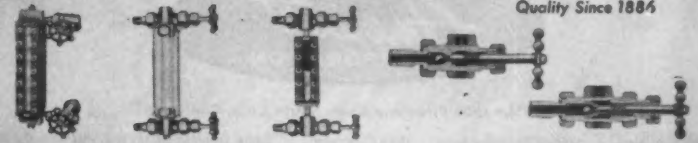

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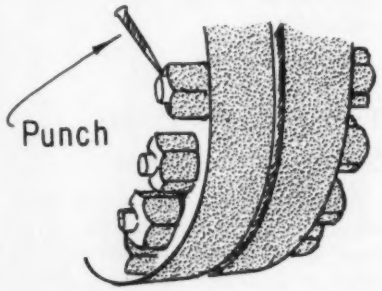
How to Do It . . .

place. When it is necessary to place one or more of the hoists near a process unit to work on a high tower, the eye which is used for towing is used to tie the unit down. The tongue should be around 9 feet long for an 18-inch-wide drum and 6 feet long for a 1-foot-wide drum to keep the line from piling up as it is wound up on the drum.

Sheaves are mounted on the ends of the tongue so that the force from the tower is directed to the anchor. The weight of the tire-mounted unit is sufficient to keep it in place.

Center Punch Used to Keep Stud Bolt Nut Tight

In cases where a nut keeps loosening up on a bolt or stud, drive a center punch into the metal at the juncture of nut and thread to form



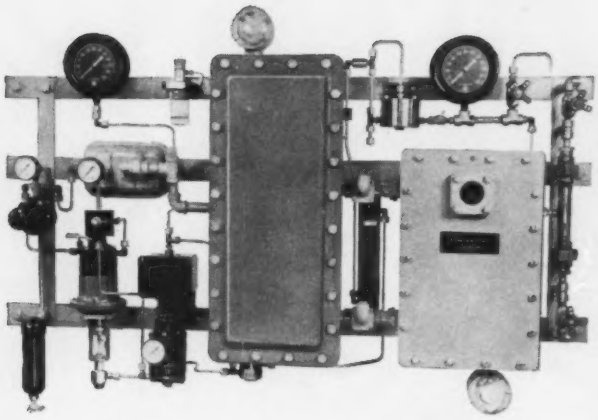
a dimple or depression. This keeps the nut in place, yet is no bar to removal when necessary.

Henry Mullen, Cleveland, Ohio

Cider Vinegar Loosens Rusty Bolts or Nuts

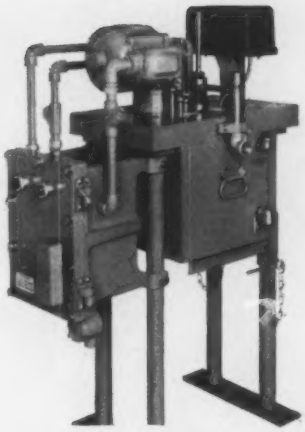
Keep a bottle of ordinary hydrogen peroxide or apple cider vinegar around for loosening rusted bolts and nuts on pipe flanges.

A few squirts of either liquid is as effective as penetrating oil, while the acid content of the vinegar prevents rust accumulating on the flange



VAPOR PRESSURE ANALYZER (left), pay out: one to three months. Continuously samples and records vapor pressure of gasoline or liquefied gases in a flowing stream.

CONTINUOUS VISCOMETER (right), decreases greatly the cost of plant operation by reducing laboratory analyses of viscosity; aids operators in fast, efficient, quality control of refinery operations. Explosion-proof design. Reliable. Rapid pay out.



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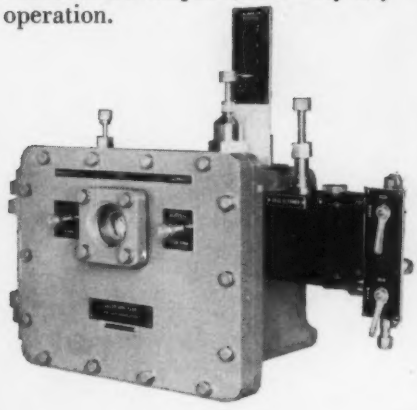
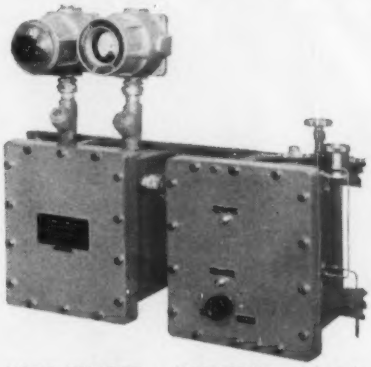


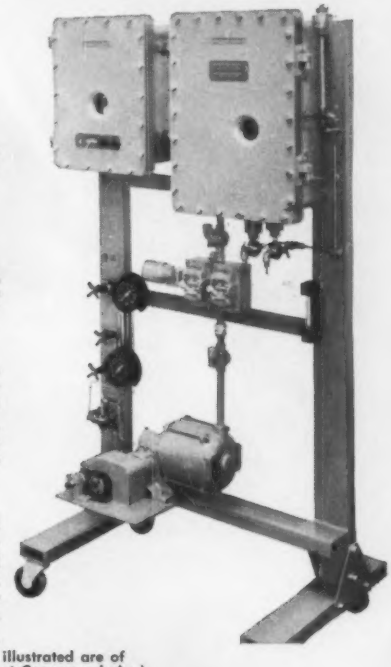
COLOR ANALYZER (above), gives electrical output signal to permit the recording of color of petroleum products in color range from pale yellow to deep red. Uses ASTM glass color-standards for calibration purposes.

Two of many other Hallikainen products (not shown): (1) *ALKYLATION ACID ANALYZER* for determining the strength of acid in sulfuric acid alkylation plants; (2) *MICROMALYZER*, a low cost, compact precision chromatographic laboratory instrument for detection of hydrocarbons.



ULTRAVIOLET ANALYZER (above), instantly and continuously measures ultraviolet absorbing components in process plant streams, such as aromatics, diolefins, ketones and aldehydes. Determinations: from few parts per million to high percentages.

BOILING POINT ANALYZERS: Pictured to the right is END POINT model. Analyzers are of two types. (1) Initial and 10%, and (2) below 90% to end point. Both models are continuous; they lower costs, give better yields and uniform products because of immediate tower control. Pay out: 30 to 60 days.



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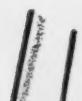


How to Do It . . .

bolts for some time after application.

Child's Toy Soap Bubble Kit Checks Gas Leaks

Space fuel of the future—in production now!

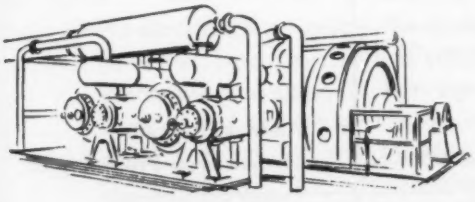
LIQUID HYDROGEN BY THE TON

99.9999% pure

Ingersoll-Rand HHE compressors help produce liquid hydrogen at world's first tonnage plant

Built and operated for the Air Research and Development Command by Air Products, Inc., U.S. Air Force Plant 74 is the world's first and largest unit for the tonnage production of pure liquid hydrogen. Here in the Florida Everglades, three Ingersoll-Rand HHE compressors are helping to produce one of the coldest substances known to man—for liquid hydrogen boils at 423°F below zero! It is also one of the most highly-purified substances known — estimated at between 99.9999 and 99.99999 percent pure!

With its high energy content and light weight, liquid hydrogen makes possible a family of super-powered chemical rockets and nuclear rockets with extremely advanced performance.



The hydrogen is produced from crude oil by partial oxidation, and is then compressed, purified and liquefied.

Used to compress three separate hydrogen streams, and also to create vacuum on nitrogen, are three identical Ingersoll-Rand HHE electric-driven compressors —among the largest such units built. These units provide the *stamina* and *versatility* so essential to sustained production at this new plant. Each HHE has three vacuum cylinders and nine compression cylinders, with the vacuum cylinders and three of the compressor cylinders operating in tandem. The HHE's unique flexibility of cylinder arrangement permits each unit to handle different gases at widely-different pressures and capacities, simplifying compressor plant layout and process-flow piping arrangements.

Ingersoll-Rand is best equipped to supply the compressor that's *right* for your job, too, because I-R builds the most complete line of compressors, in reciprocating, centrifugal, axial-flow, rotary and thermal types. There are units from ½ to 20,000 hp, for pressures from one micron to 125,000 psi. Your I-R representative can give you valuable help—call him today.

Ingersoll-Rand®

278-A-1 ♥ 11 Broadway, New York 4, N.Y.

THE WORLD'S MOST COMPREHENSIVE COMPRESSOR EXPERIENCE

CATALOG B-1

Don't Give an Inch — to FOAM

use Dow Corning Silicone Defoamers*

There's a *right* tool for every job. In foam control it's Dow Corning silicone antifoamers or defoamers . . . job-proved thousands of times over as the most efficient, most economical, and most versatile foam suppressors available.

*At prescribed levels, are sanctioned by FDA

FREE SAMPLE
and new manual on foam control

first in silicones

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CORPORATION
MIDLAND, MICHIGAN

Dept. 9821

Please rush a FREE SAMPLE of a Dow Corning silicone defoamer for my product or process, which is (indicate if food, aqueous, oil or other): ----------

NAME _____

POSITION _____

COMPANY _____

ADDRESS _____

_____

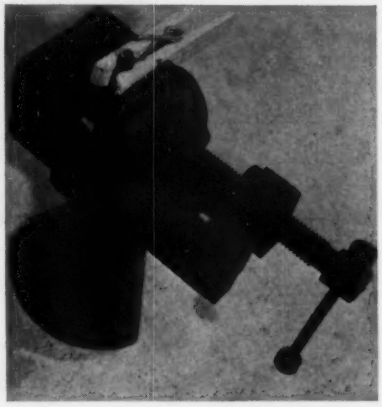
How to Do It . . .

bolts for some time after application.

H. Josephs, Gardenville, Pa.

Clothespin Holds Tubing In Vise for Filing

When you have to file or do other work on small tubings like those used in plant instrumentation, the tubing



is clamped in the groove of a spring-type clothespin, then in the vise. The clothespin holds the tubing better than does the smooth jaws of a vise, and prevents damaging the piece.

Harry J. Miller, Sarasota, Fla.

For Easier Reading Loop Wire Around Volt-Ammeter

In some cases when using a clamp-on volt-ammeter to read current draw on metering instruments or other electrical equipments, the current drain is so small that easy, accurate readings are difficult.

In such cases, simply loop 10 turns of one feeder wire through the jaws of the clamp-on meter, thus it will multiply the reading by 10. For example, a unit drawing .2 amp will give a reading of 2 amperes.

Many times, looping the feeder wire only two or three times is enough to obtain an easily-read scale deflection.

Item by Harvey Miller, Danboro, Pa.

Child's Toy Soap Bubble Kit Checks Gas Leaks

When checking for gas leaks, air leaks, etc., around connections, children's toy liquid bubble soap is far superior to conventional soap suds which have a habit of dropping off.

The bubble soap, painted on connections, detects the slightest leak and reveals it with a stream of bubbles.

Item by H. Josephs, Gardenville, Pa.

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Handling costs compel Gulf Publishing Company to make a charge of 10 cents per page (minimum 25 cents) for all TEAR SHEETS ordered. Such tear sheets will be sent, when available, if cash (or company requisitions) is sent with the order.

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Warren and Water Streets, Sandusky 1, Ohio

Who's Building in HPI...

Rimbey Gas Plant: Canada's Largest

Propane, butane, condensate and sulfur are major products of $12.5-million facility

Adding 326 MMcf of raw gas processing capacity to the Canadian natural gas industry, Canada's largest natural gas processing plant has opened as a joint-interest venture of 27 companies.

Operated by British American Oil Co., the $12.5-million plant is situated between the Westerose South (Dick Lake) gas field to the north and the Homeglen-Rimbey gas and oil field to the south. Processing gas from both these fields, the facility is about 90 miles southwest of Edmonton, Alta., near the central Alberta town of Rimbey.

Plant production will include a daily capacity of 86,000 gallons of propane, 112,000 gallons of butane, over 12,600 barrels of condensate and 250 long tons of sulfur.

View of Rimbey gas plant from the east shows the gas treating section to the left of the 250-foot chimney and liquid hydrocarbon processing facilities to the right of the stack.

Construction, which began in February 1960 and ended in January 1961, was handled by Poole-Pritchard Canadian, Ltd. British American supervised the design and construction.

Quick Look at Plant's 'Firsts'

- First major gas plant in Canada to use "outdoor-type" construction (process units not protected by buildings).
- First gas plant in Canada to serve more than one field on a joint-interest basis. Twenty-seven companies own shares of the plant's capacity according to their interests in either or both the Westerose South (Dick Lake) and Homeglen-Rimbey fields.
- Use of centrifugal compressors instead of more conventional reciprocating compressors in the plant's refrigeration system was made possible by the plant's large size.
- Hydraulic turbine used for power recovery in the plant's amine system is a "first" for Canada and one of the first in this service anywhere.
- High-pressure demethanizers used at two points in the plant's gas processing system reduce recompression horsepower that otherwise would be required—another first for Canada.
- First plant of its size in Canada to have no cooling water system as such. Aerial coolers are used for all process cooling.

INLET FACILITIES

Since there are producers in each field who have no interest in the other, the incoming gas stream from each field is fed into its own inlet separator and demethanizer unit. The gas and liquids coming from each are separately metered and sampled for the calculation of producers' interests.

The inlet units are of 1,100-pound design, and the streams of gas enter the plant at approximately 950 pounds pressure.

Under normal conditions, parallel streams of liquids from the inlet separators are pumped into the liquid demethanizers. The partly demethanized liquid stream from the bottom of each demethanizer flows, after metering, to the condensate stabilizer.

The vapors from the top of each demethanizer are returned to their respective inlet separators where they

S-R MATIC BRAIN

FOR STORAGE FIELD OPERATION AT ILLINOIS POWER COMPANY

Another achievement of S-R Matic—The Illinois Power Company natural gas storage field engineered for automatic injection or withdrawal as well as concurrent injection and withdrawal in multiple storage fields. Telemetered remote command for pressure and flow is verified and monitored by complete automatic station supervisory control.

S-R Matic may also include computer control for variable conditions to produce optimum operation of storage and supply. We offer a consulting service in overall automation to effect the most for your investment in efficiency, long range economy and optimum system supervision. Let us help you plan your automation future.

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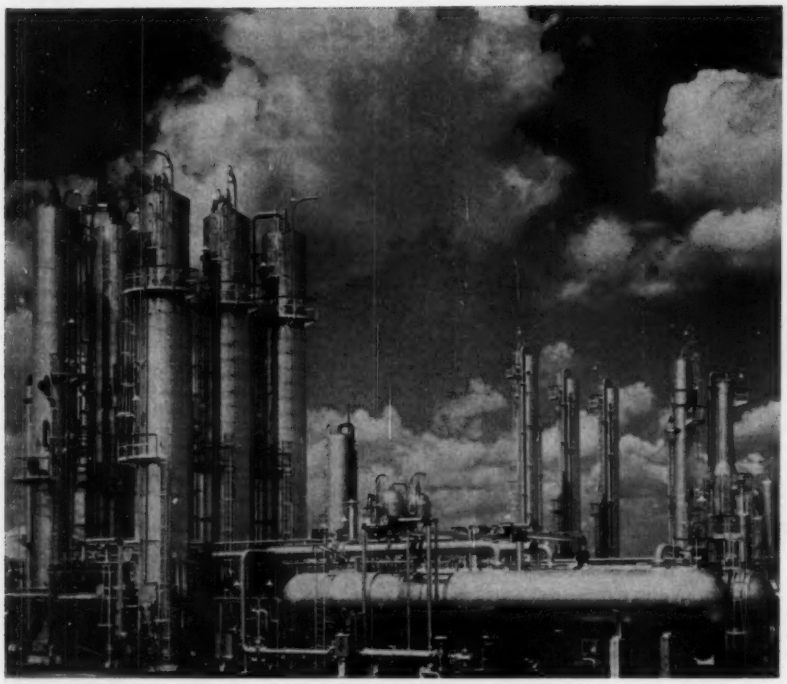


From raw gas to pipe line gas: Rimbey gas plant's high-pressure gas section.

are mixed with the main gas streams. After metering, the gases from both fields are combined into a single stream.

GAS TREATING

The gas stream meets pipeline specifications for acid gas content after monothanolamine-type gas treating facilities remove essentially all of the H_2S and CO_2. Three high-pressure amine contactors—each of 1,100-pound design—remove acid gases from the main gas stream and a low-pressure contactor removes acid gases from the light hydrocarbon stream that comes from the top of the condensate stabilizer.

Amine solution is pumped into the contactors from the amine regeneration system. The circulation of approximately 2,500 gallons per minute of 20-percent amine solution is required to remove the acid gas from the natural gas stream.

HYDROCARBON WATER DEW POINT UNITS

The natural gas from the contactors is rich in hydrocarbon liquids that must be condensed from the stream before the gas can meet pipeline dew point specifications. Condensation is brought about in two parallel dew point control units which utilize heat exchangers and propane refrigeration chillers to cool the stream.

Water dew point is depressed and ice and gas hydrate formation is prevented in the chilling equipment by injecting a glycol solution into the gas streams ahead of the exchangers and chillers.

The main gas stream plus the condensed liquids enter the low-temperature separators where the condensed hydrocarbon liquids and glycol-water solution are removed. The gas stream then re-enters the heat-exchangers to pre-cool the unchilled gas and, after metering, goes out of the plant to pipeline sales.

The partially demethanized hydrocarbon liquid from the bottom of the low-temperature separators flows to the deethanizer feed drum. The glycol, separated from the liquid stream, flows to the glycol regeneration system.

CONDENSATE STABILIZATION

In the condensate stabilizer, H_2S and other light ends are fractionated from the raw condensate received in the inlet separators and a butane-free natural gas condensate produced as the bottoms product.

The stabilized condensate flows to storage which consists of three 20,000-barrel atmospheric storage tanks. The plant can produce 12,600 bpd of condensate, including the natural gasoline fraction from the debutanizer.

LIQUID FRACTIONATION

The fractionation process is of the conventional cascade type. Feed from the deethanizer feed drum is heat-exchanged and fed into the deethanizer which is designed to recover the bulk of the propane and heavier liquids in this feed. The liquid from the refrigerated condenser is refluxed to the deethanizer tower. The surplus net overload vapors not required for fuel are re-compressed to 950 pounds and mixed with the main gas stream.

The bottom stream from the deethanizer is fed into the depropanizer. The propane goes directly to four 60,000-gallon storage tanks.

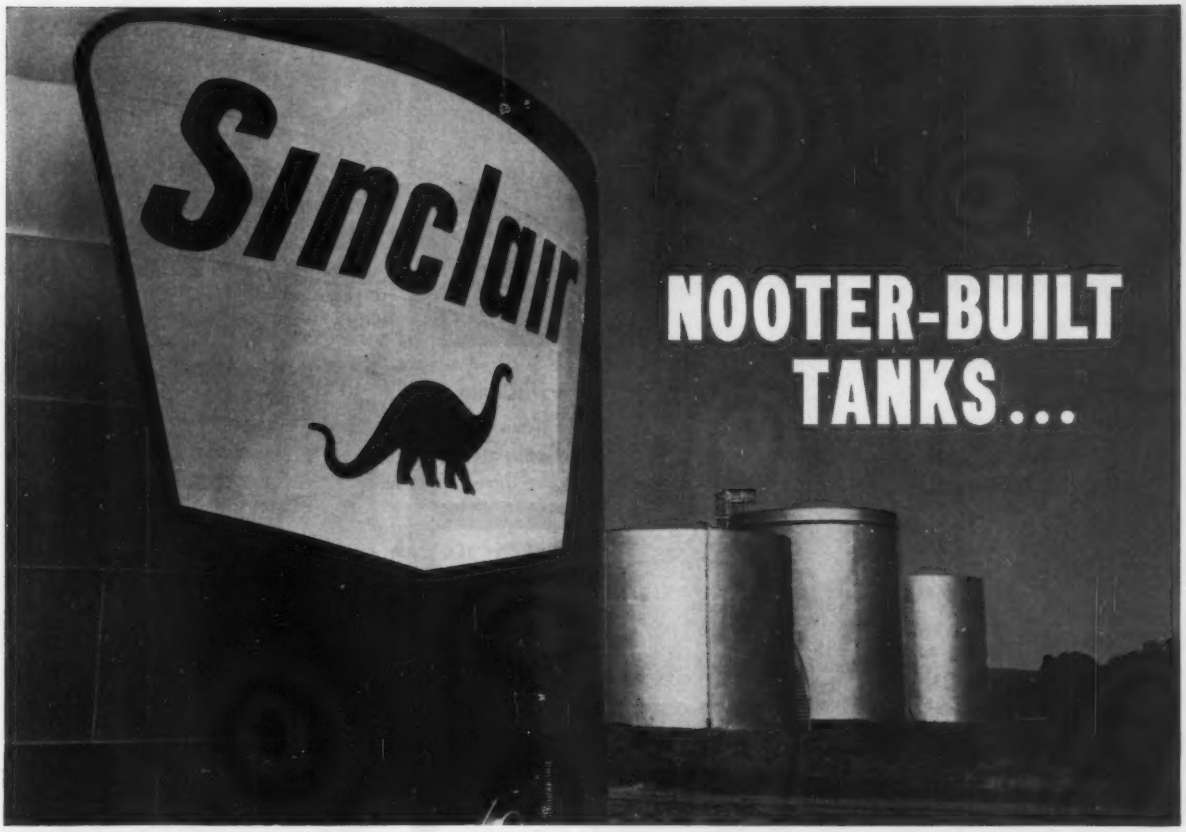
SULFUR RECOVERY UNIT

Elemental sulfur is produced from the acid gas stream. In the sulfur recovery unit, acid gases from the amine still reflux accumulator are partially burned in sulfur boilers which generate 175-pound steam. The gases from the sulfur boilers pass through two catalytic reactor stages. The sulfur condensers produce 35-pound steam.

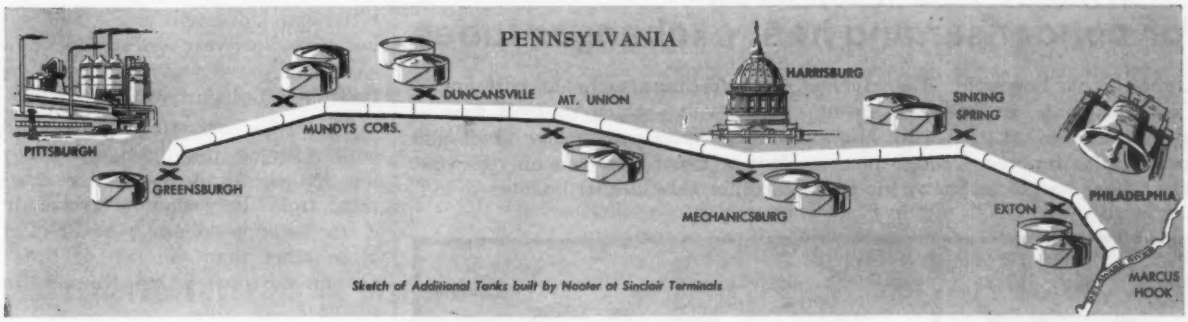
Cyprus Mines Corp., Los Angeles, will construct and operate three plants in Texas, Oklahoma and Louisiana for the removal of liquid products from natural gas. The plants, which will be in areas not served by large absorption facilities, will cost about $500,000 each. Cyprus Oil Co. Division, Houston, will manage the operations.

U.S. Steel Corp. has gone on stream at Clairton, Pa., with a new tar distillation plant. Two identical distillation units, each containing multiple fractionating columns, produce a variety of coal chemicals from gas driven off when coal is burned to coke.

Coastal Chemical Corp. will increase its ammonia capacity at Pascagoula, Miss., to 140,000 tons per year. Included in the $4.5-million cost is offsite atmospheric pressure storage for anhydrous ammonia. Coastal's first ammonia plant, which had a 54,-



...added to Sinclair terminals on the Laurel pipe line



Sketch of Additional Tanks built by Nooter at Sinclair Terminals

To provide more petroleum products for communities along the Laurel Pipe Line in Pennsylvania, Sinclair Refining Company has modernized and enlarged seven of its storage terminals fed by the big line, which sweeps across the state from Sinclair's Marcus Hook, Pa., Refinery. Sinclair terminals in Pennsylvania now total 35,300,000 gallons capacity.

Thirteen new storage tanks were erected by Nooter for the terminals shown above, including both the cone roof type and the floating roof type. Nooter floating roof tanks feature a patented 2-point suspension seal hanger which provides a more positive seal, eliminates local abrasion, extends the life of the sealing ring and reduces maintenance cost.

Take advantage of Nooter's expanded services on bulk storage tank fabrication and erection, extending to all parts of the country. Check with Nooter on your next job, for cost saving estimates and dependable deliveries.

Write for Bulletin 158—Nooter Floating Roof Storage Tanks.

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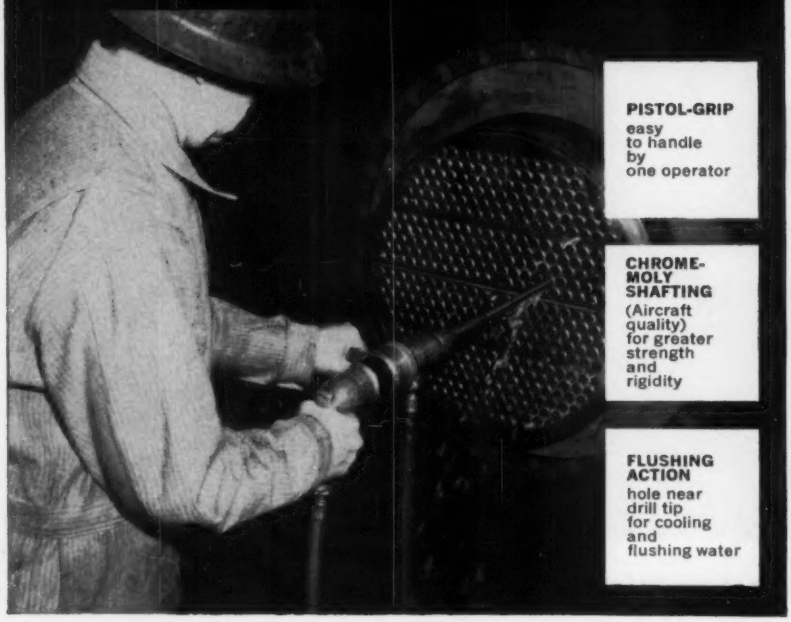
1404 SOUTH THIRD STREET • ST. LOUIS 66, MISSOURI

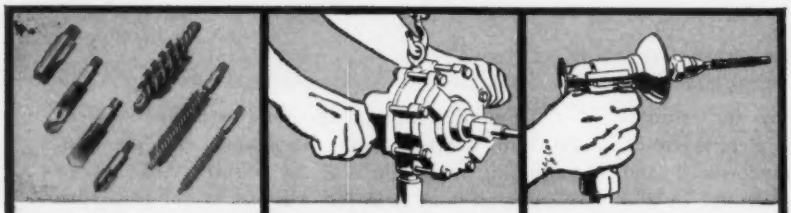
newest ELLIOTT tube cleaner

lightweight! air-driven!


PISTOL-GRIP
easy to handle by one operator
CHROME-MOLY SHAFTING
(Aircraft quality) for greater strength and rigidity
FLUSHING ACTION
hole near drill tip for cooling and flushing water

for condenser and heat exchanger tubes

Lightweight. Powerful. Air-driven. Trigger-action control with speed governor to prevent shaft-whip. High-speed motor reduced through planetary gears to 1500 rpm. Integral water-feeding attachment with finger-action valve which controls flow of cooling water into hollow shaft and drill or brush. Built-in oil reservoir. Send for tube cleaner bulletin Y-48.



DRILLS AND BRUSHES FOR VARIED NEEDS
Brushes for light deposits. Four types of drills clean light, hard-heavy, hard-light, and gummy deposits.

SUSPENSION TYPE
Air, steam or electric heavy-duty motor, for removing hard, heavy deposits. Ball bearings absorb thrust in either direction.

ELLIOTT JIFFY GUN
For extra-fast cleaning of light deposits in tubes ½ in. to 1¼ in. Air or water pressure shoots nylon brushes or rubber plugs through tubes.

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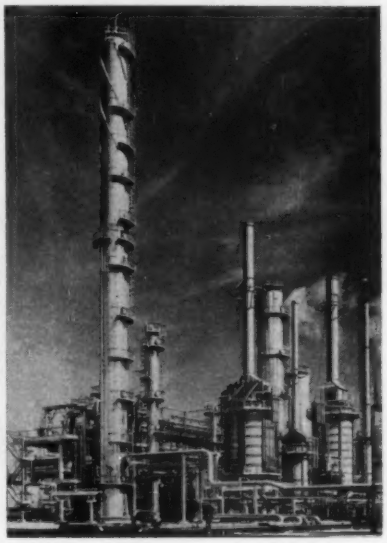
Y1-3

Building . . .

000-ton capacity, was built by Chemical Construction Corp.

Aromatics Unit Completed At Cities Service Plant

Cities Service Refining Corp.'s new aromatics plant is complete and on stream at its Lake Charles, La., refinery. The facilities, consisting of an



8,100-bpd Udex unit and a 120-million-pound-per-year orthoxylene unit were engineered and constructed by Badger Manufacturing Co.

The orthoxylene unit is believed to be the largest ever built specifically for petrochemicals. Product is separated from the remaining xylenes in a fractionating column over 220 feet high rather than the two or three-column systems normally used in plants of this type.

Sun Oil Co. will build an 84,000-bpd fluid catalytic cracking unit at its Marcus Hook, Pa., refinery. This facility will replace a fixed-bed cat cracker that has been operating for 21 years. Planned to go into operation in October 1962, the catalytic cracker will cost over $14 million. It will be the largest single cat cracker ever installed by Sun.

Shell Oil Co. has completed an expansion project at its Weeks Island, La., facility. Plant Service Construction Co., Baton Rouge, La., was general contractor for the job, which

6 WAYS Howe-Baker Custom-Designed ELECTRICAL DESALTING PAYS OUT FOR YOU (AT RATES UP TO 250% PER YEAR!)

Benefits of modern Howe-Baker electrical desalting units reach far beyond the simple removal of salt from crude charge stock. In fact, many refining experts recommend electrical desalting, regardless of the initial salt content in the crude. The old rule-of-thumb that called for electrical desalting only when salt content exceeded 20 lbs. per thousand barrels of charge stock no longer applies . . . Howe-Baker units operating with charge stock having no more than 5 lbs. salt per thousand barrels of crude are paying out satisfactorily. Here are the reasons why:

1 INCREASED CRUDE CAPACITY

because thorough water removal increases heat transfer rates (water requires about 9 times more heat than equal oil volume). Plus capacity gains through less downtime needed for cleaning.

2 REDUCED MAINTENANCE

costs with Howe-Baker desalting have been established positively with "before-and-after" records. Savings occur in cleaning, repairs and replacement.

3 IMPROVED CRACKING YIELDS

because Howe-Baker units remove virtually all water-soluble and suspended solids—which include a large portion of catalyst-poisoning metals. Effective salt removal also prevents salt catalysis formation of cokes and tars.

4 REDUCED CRACKING IN DISTILLATION

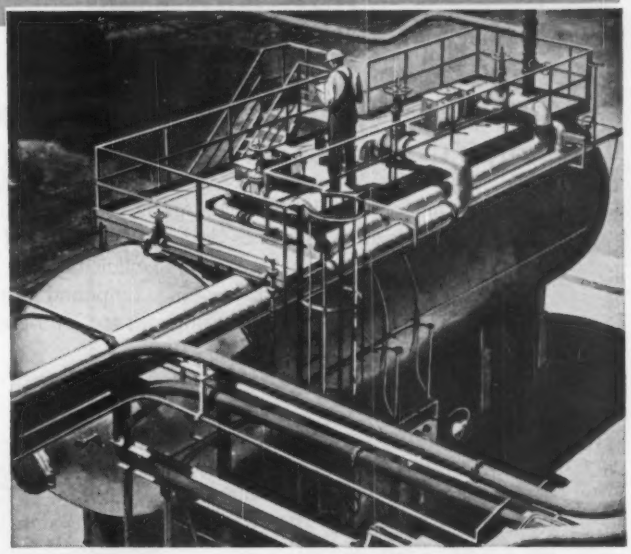
with salt and solids-free charge stock. Less deposits also mean reduced tube failures and fewer hot spots in furnaces.

5 REDUCED CORROSION

benefits alone can save 0.6¢/bbl. of throughput. Salt, hydrolyzed to HCL in untreated stocks, creates critical corrosion conditions which are eliminated with efficient Howe-Baker desalting.

6 INCREASED TANK CAPACITY

is achieved with Howe-Baker desalting because thorough removal of BS&W makes possible the lowering of crude suction lines to the tank bottom, and eliminates tank cleaning. From 2 to 8% of tank capacity is usually gained by this removal of BS&W.



. . . And HOWE-BAKER Follow-Through Assures These Pay-Out Results

Howe-Baker not only custom designs electrical desalting units to fit the specific requirements of your refinery, but follows through from plant layout to operator instruction to assure the results you expect—and get—from Howe-Baker equipment. These services include: Detail and assembly drawings and specifications of all equipment. Availability of a qualified engineer to discuss any technical aspects of Howe-Baker processes, and to assist in plant layout. Operating and maintenance manuals prepared and supplied in quantities needed. Engineering supervision of assembly of Howe-Baker equipment; and assistance to assure proper installation of auxiliary equipment. An engineer-instructor to give operating, technical and maintenance personnel thorough grounding in proper methods of operating and maintaining the plant; and to assist in initial startup of the unit. Follow-up visits by an engineer to check operation, and to assist in solving any technical problems that might arise.

If you are planning a new refinery—or anticipate modernizing existing facilities—now is the time to ask Howe-Baker for details on custom-designed electrical desalting that will help you achieve highest standards of operating efficiency. Call or write for prompt action.

HOWE-BAKER ENGINEERS, INC.

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Turco Products uses Borg-Warner Mechanical Seals exclusively

keep bearings from being "cleaned out" on Turbulator Cleaning Machines!

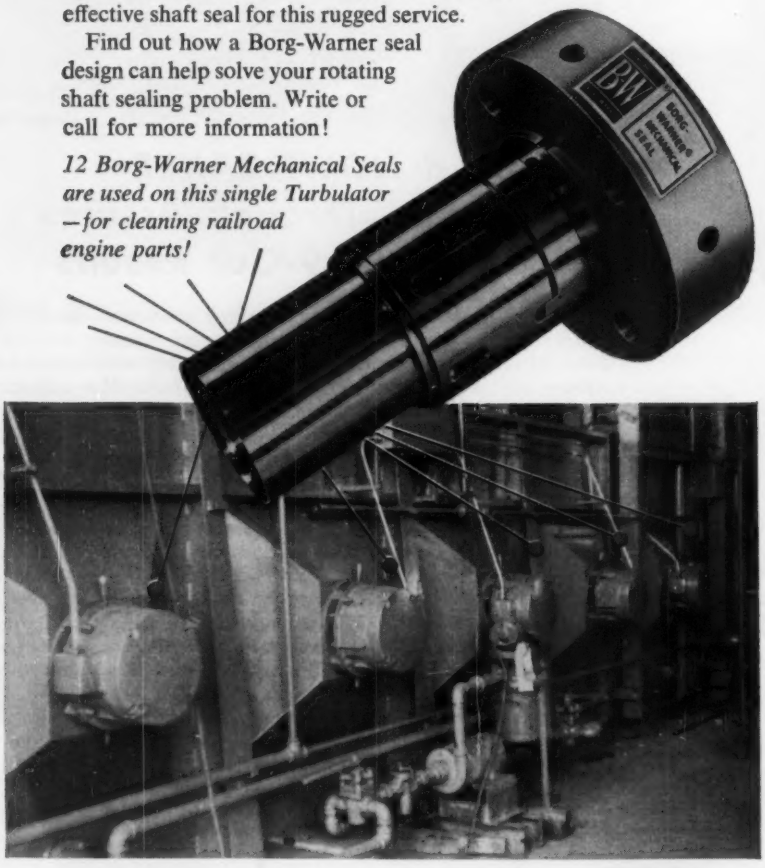
From jet engines to railroad engine parts, Turco Products, Inc. "Turbulator" cleaning machines do an amazing job of cleaning every bit of a part or product quickly and efficiently.

But any leakage of this same cleaning compound past the propeller shaft can clean out bearing lubricant too, and costly bearing failure would result.

That's why Turco has standardized on Borg-Warner Mechanical Seals for all Turbulator units as the most effective shaft seal for this rugged service.

Find out how a Borg-Warner seal design can help solve your rotating shaft sealing problem. Write or call for more information!

12 Borg-Warner Mechanical Seals are used on this single Turbulator —for cleaning railroad engine parts!



Borg-Warner Mechanical Seals

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Building . . .

included installation of two 1,320-hp compressors, 2,000 feet of 12-inch pipe line, dehydration heaters, coolers, etc.

Standard Oil Co. of California has disclosed that plans for its new Alaskan refinery are progressing so rapidly that completion will be prior to the scheduled mid-1963. (HYDROCARBON PROCESSING AND PETROLEUM REFINER, June 1961, Page 242.)

Gulf Oil Corp. plans to partially rebuild and completely modernize its Cincinnati, Ohio, refinery. The multimillion-dollar construction program, expected to begin late this year, will be completed by the fall of 1962. Bechtel Corp. of San Francisco has been awarded the construction contract.

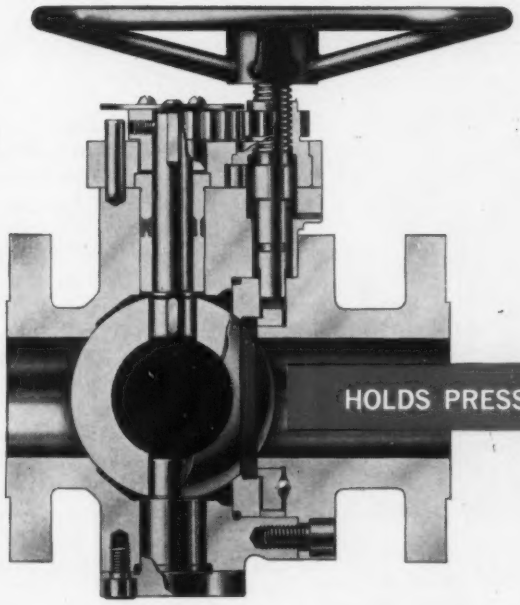
The major portion of the rebuilding program will include the installation of an atmospheric and vacuum crude distillation unit; an alkylation unit, for the production of high-octane components for use in motor gasolines; a "Gulfiner," for the production of home heating oils; a CO boiler; plus the complete renovation of several existing facilities. The refinery's current crude runs to stills average about 28,000 bpd. After modernization, crude runs are expected to be 32,000 bpd.

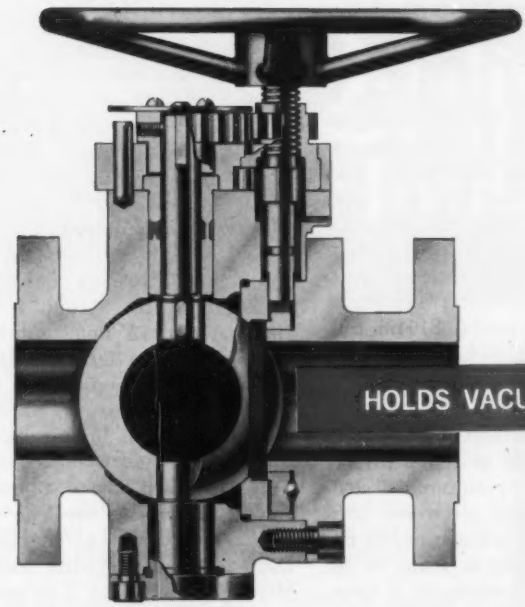
Linde Co. has awarded a subcontract to Chemical Construction Corp. to design and build the hydrogen synthesis section of its 21-ton-per-day liquid hydrogen facility at Fontana, Calif. Linde has signed a $31-million contract with the National Aeronautics and Space Administration to supply West Coast rocket centers. Completion is set for June 1962.

Chemetron Corp.'s National Cylinder Gas Division will build a $1-million plant at Dallas, Texas, to make liquid gaseous products. Initial capacity will be 120 tons per day of oxygen, nitrogen and argon.

Allied Chemical Corp. will begin construction of a plant to manufacture phthalic anhydride on the site of its present plant at El Segundo, near Los Angeles, Calif. The plant will employ the Von Heyden-Chemiebau

Exclusive Controlled Compressible Port Seal provides fast, positive shutoff in any service...





HYDRIL

BALL PLUG Type "K"

VALVES

Controlled sealing . . . a new concept in valve design . . . is the secret of Hydril's tight, bubble-proof shutoff. Hydril Ball-Plug Valves always seal positively against pressure from either direction—or against vacuum—because the fully confined packing ring is mechanically compressed between plug and seat when the valve is closed. This tightly compressed gasket type seal easily bridges clearances between parts as well as surface imperfections. Result: seal efficiency is unimpaired by prolonged hard usage, by rust or sediment.

Design of Hydril Type "K" Ball Plug Valves assures minimum maintenance costs. Non-lubricated, they employ no sealing lubricants. There's no sliding friction between plug and body to produce wear and abrasion.

The spherical plug is mounted on accurately positioned bearings, maintaining a minimal controlled clearance between plug and body. This contributes to easy, free-turning operation as well as to long service life.

●

Hydril valves are available in a wide range of sizes and ratings. Worm-gear and motor-operated models can be supplied. Get the full story on Hydril Valves from your nearby representative . . . or write Hydril Company for free Catalog No. V-60.

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Sales Offices: California: Bakersfield, Los Angeles, Ventura • **Louisiana:** Harvey, New Iberia, Shreveport **Oklahoma:** Oklahoma City, Tulsa • **Texas:** Corpus Christi, Dallas, Houston, Midland, Odessa • **Wyoming:** Casper **New York:** New York • **Canada:** Calgary, Edmonton

For more data on advertised products, use cards, last page.

SADI
VALVE OPERATORS
Adaptable to NEW and EXISTING VALVES

THOUSANDS of operators in service throughout the world, typical examples of SADI power transmission equipment quality

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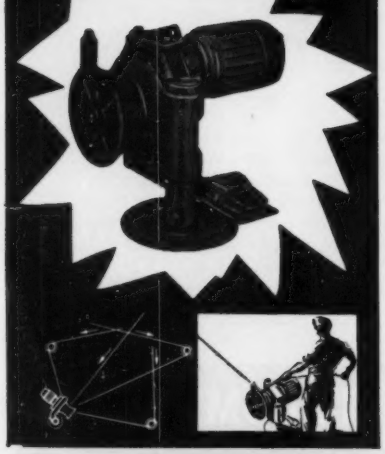

SADI S.P.R.L.
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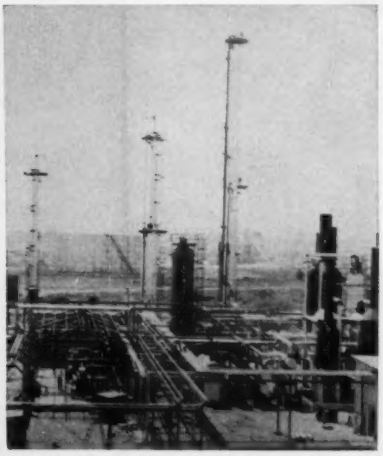
BRUSSELS 19 — BELGIUM

Building . . .

process, which can utilize a variety of raw materials. The new facilities are scheduled to be in production by the latter half of 1962. The construction contract has been awarded to Ralph M. Parsons Co. of Los Angeles.

Powerine Oil Gets New Refining Unit

A new $2.5-million refining unit which will boost daily production of 100 plus octane gasoline by 50 percent and permit refining a new olefin-



free 102 octane premium gas will be built by Powerine Oil Co. at its Santa Fe Springs, Calif., refinery. The installation, a Lomax unit, was engineered by Universal Oil Products Co.

Texas with $862.6 million ranks as the top state in the U.S. in terms of total chemical construction funds, according to a recent survey by Manufacturing Chemists' Association, Inc. Other states in the "top ten" are: Louisiana, $278 million; California, $195 million; Ohio, $191.4 million; Pennsylvania, $176.3 million; New Jersey, $173.7 million; Tennessee, $154.4 million; Florida, $141.3 million; Kentucky, $120.4 million; and Michigan, $113.3 million.

Texaco, Inc., has built a lubricating oil blending facility at River Rouge, Mich., to be run by automated electronic controls. The electronic control system enables a single technician to mix automatically as many as six additives and base stocks at a time. Base oils will come from Texaco's Port Arthur, Texas, refinery.

National Petrochemicals Corp., jointly owned by National Distillers and Chemical Corp and Owens-Illinois Glass Co., is building a 60-million-pound-per-year linear polyethylene plant next to U.S. Industrial Chemicals Co.'s plant in Houston. USI, who will operate the new plant, is a division of National Distillers.

Humble Oil & Refining Co. has let a construction contract to Hudson Engineering Corp. for a 40,000-Mcfd gas processing plant in Crane County, Texas. The facility, to be known as the Sand Hills gas treating and processing plant, is scheduled for completion late this year.

Cary Chemicals, Inc., has selected a site for a new 100-million-pound-per-year polyvinyl chloride plant. Options have been obtained on a 66-acre parcel in Burlington Township, just west of Burlington, N. J. (HYDROCARBON PROCESSING AND PETROLEUM REFINER, August 1961, Page 158.)

Union Carbide Chemicals Co.'s plant at Brownsville, Texas, is now in production. The first major chemical being produced is acetic acid. Others presently scheduled are acetic anhydride and methyl ethyl ketone. This is the company's eighth chemical plant and its third in Texas. Other Texas installations are at Seadrift and Texas City.

Houdry Process Corp. will more than double its production capacity for triethylenediamene through construction of a second plant at Paulsboro, N. J. Catalytic Construction Co. of Philadelphia will handle construction of the plant, which is scheduled for completion by the end of this year.

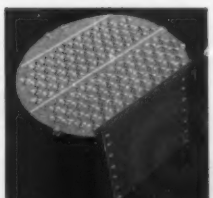
Florida Hydrocarbons Co. plans to complete a $7-million natural gas processing plant at Brooker, Fla., sometime in the second quarter of 1962. About 45 miles southwest of Jacksonville, the facility will have a 330-MMcfd capacity, with recovery of 45,000 gallons of gasoline and 90,000 gallons of butane daily.

Gulf Oil Corp. plans to more than double its present ethylene capacity with a new plant to be built on a 1,000-acre site on Cedar Bayou near Mont Belvieu, Texas. The new plant, located approximately 30 miles east of Houston, will have an ethylene ca-

From Calgary to Chachapoyas — Koch Engineering Company is known, respected, and relied on — for the continued quality of their products.

At Koch Engineering, top-flight engineers — exceptional in the technical proficiency of their fields — combine their skills with the latest and most modern equipment and materials . . . to produce products that are often imitated — but seldom equalled!

One of these is the low-cost Koch Flexitray — most economical device yet developed for distillation, absorption, and stripping. For your next tower installation, keep the Koch Flexitray in mind. The *quality* of this superior fractionating tray can *not* be imitated!



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See our catalog in "Refinery Catalog" — or contact your nearest Koch Representative.

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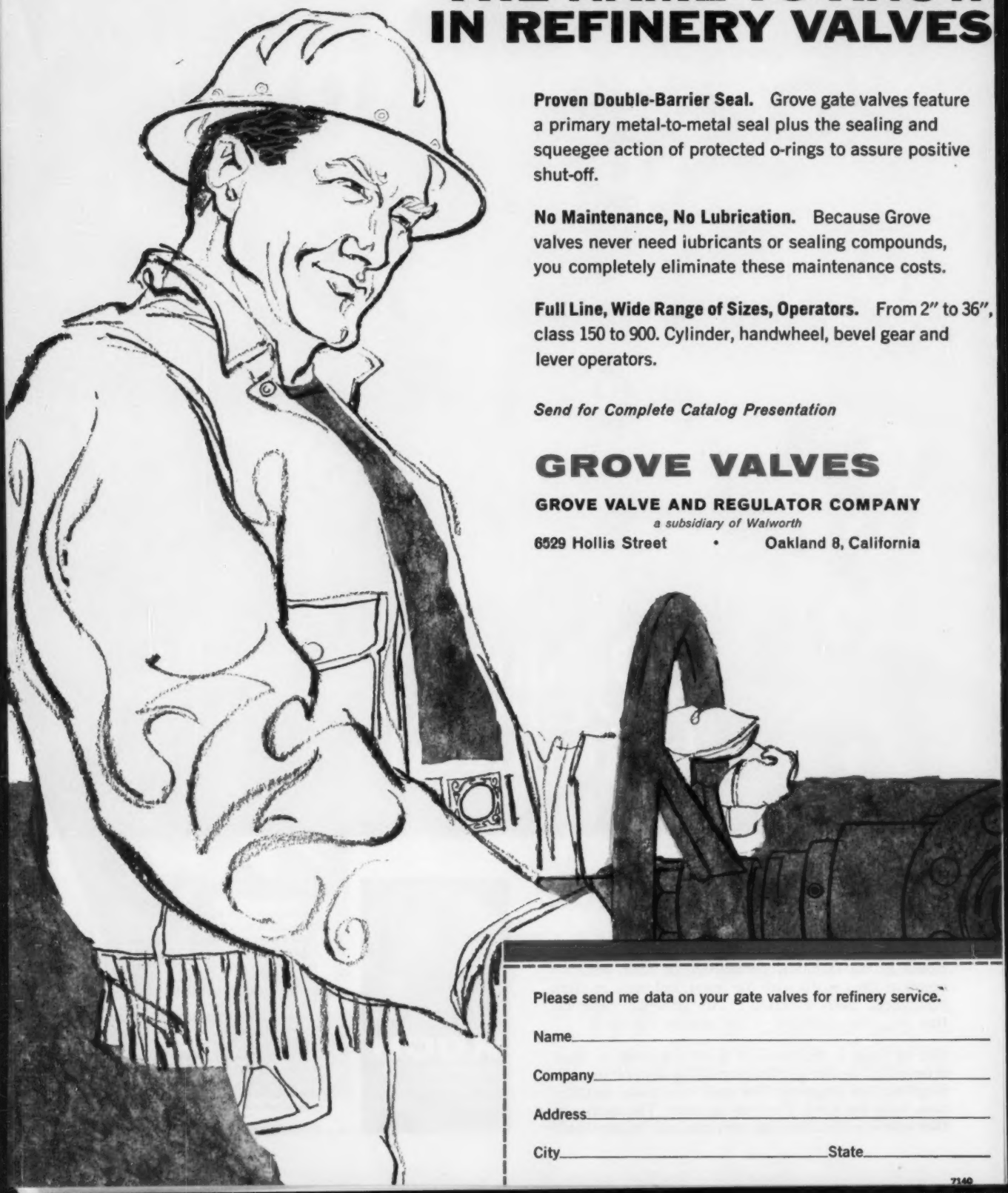

Proven Double-Barrier Seal. Grove gate valves feature a primary metal-to-metal seal plus the sealing and squeegee action of protected o-rings to assure positive shut-off.

No Maintenance, No Lubrication. Because Grove valves never need lubricants or sealing compounds, you completely eliminate these maintenance costs.

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Please send me data on your gate valves for refinery service.

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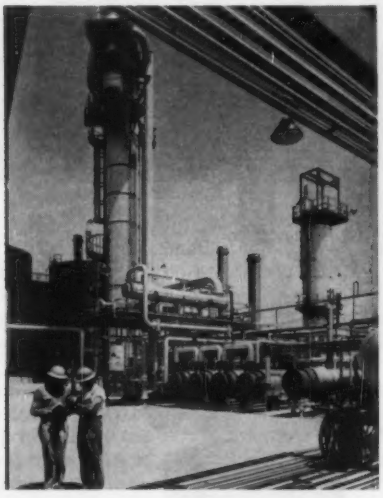
7140

pacity in excess of 400 million pounds yearly. Engineering work is completed and construction will start this fall. Completion date is set for mid-1963. In addition to the ethylene plant, Gulf plans to utilize the site for an extensive petrochemical complex. Additional facilities, including a high-purity propylene plant to be constructed at an early date, will be added to the Cedar Bayou plant to provide a fully integrated, grass roots installation.

Cities Service Co. has signed a contract with the Secretary of Interior for construction of one of the largest helium extraction plants ever designed in the United States. The contract calls for a plant on an 80-acre sight near Ulysses, Kan., with a capacity to deliver 2 MMcfd of helium. In producing the helium, Cities Service will process 505 MMcfd of gas. The plant is expected to begin operation early in 1963. Existing extraction plants are five smaller units now operated by the Bureau of Mines.

'Gulfinishing' Process Completes Trial Run

Gulf Oil Corp. has completed trial runs of its new lubricating oil unit at the Port Arthur, Texas, refinery. The 13,000-bpd installation was developed by Gulf researchers and constructed by Bechtel Corp. of San Francisco.



Known as "Gulfinishing," the operation is extremely flexible, not only from the standpoint of daily operations, but also from maintenance. Designed as twin units, each with a capacity of 6,500 bpd, the operators can choose from more than 12 different feed streams and quickly make the necessary operating adjustments.

Principal advantages of "Gulfinishing": Lower processing cost, higher yields, and better product.

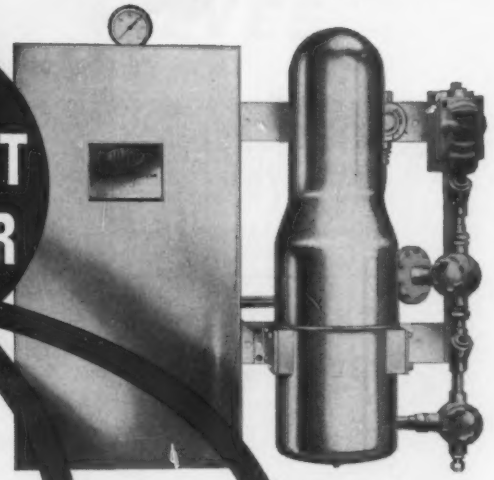
With "Gulfinishing" in full operation, the refinery no longer requires clay contacting, percolation, filtering, and acid treating. Units handling these processes have been brought off the line and will be dismantled.

Ashland Oil & Refining Co. has completed a Udex unit at its Ashland, Ky., refinery to produce benzene, toluene and xylene. (HYDROCARBON PROCESSING AND PETROLEUM REFINER, June 1961, Page 242.)

Standard Oil Co. of California and Humble Oil & Refining Co. have awarded a contract to Southwestern Engineering Co. for the construction of a gasoline recovery plant at Carpinteria, Calif. The new facility will replace three rented units now in service and will boost handling capacity to 20 MMcf of natural gas

now on-stream

TOTCO END-POINT ANALYZER



optimum returns through quality control

Among companies now using one or more Analyzers for monitoring or controlling are:

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Permits closer control to end-point specifications and increased yield. Continuous analysis improves quality. Write for Bulletin 6000-11.

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MASONEILAN D/R ACTUATOR and AXIAL POSITIONER

Air to open Actuator with axial positioner

Air to open without positioner

PROVIDE New Versatility IN LOW FLOW CONTROL VALVES

The new Masoneilan D/R Actuator, plus the exclusive Axial Positioner, provides a versatility particularly useful in laboratory and pilot plant applications. A single valve and positioner can be used in as many as four different combinations — direct or reverse action, each with or without positioner. The advantage of such versatility in lowering original and inventory costs is apparent. In process applications, also, where systems may be subject to periodic change, such a valve can be a moneysaver.

The valves are available with ⅜″ or ½″ globe or split body designs powered by the D/R 14 actuator; and with ½″, ¾″ or 1″ globe or angle bodies powered by the D/R 25 actuator. A wide selection of trim sizes is available with C_V ratings ranging from .016 to 5.4.

The positioner provides precise positioning in either air-to-close or air-to-open action and may also be used for split-ranging.

Get complete data from any Mason-Neilan representative or write direct.

Products that Work for Your Profit . . .

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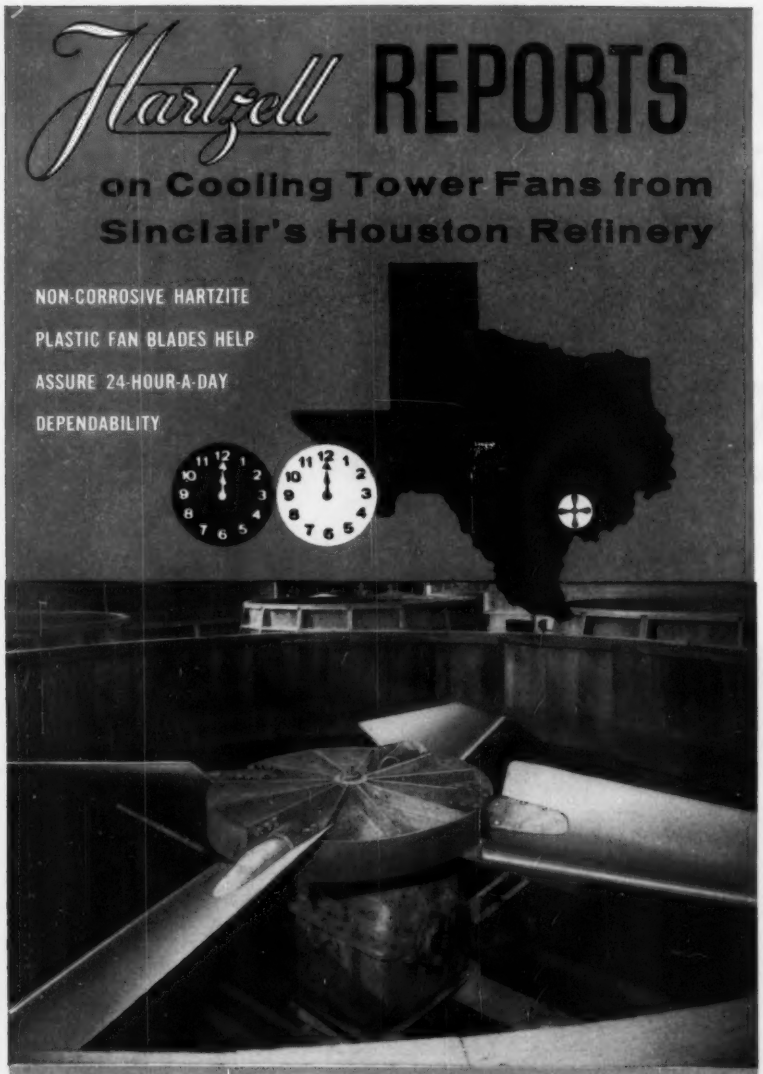

At Sinclair's Houston Refinery, six 16-foot cooling tower fan blades made of non-corrosive Hartzite plastic have been delivering 24-hour-a-day dependability for over five years.

Exclusive Hartzite plastic has been proved on thousands of installations in chemical plants, refineries and power plants to be the material most resistant to corrosion and mechanical damage. It absorbs vibration and its strength is far greater than required to withstand normal stresses. In addition, adjustable-pitch, tapered blades are heavily reinforced.

Hartzell designs and manufactures cooling tower and heat exchanger fans to cover every application. It will pay you to get all the facts from your nearby Hartzell representative, or, write direct for your copy of Bulletin A-111C.

Hartzell PROPELLER FAN COMPANY
PIQUA, OHIO
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HARTZELL

Building . . .

daily. Completion of the $500,000 installation is scheduled for January 1962.

Mobay Chemical Co. plans to erect additional facilities for the production of organic isocyanates. The addition will be next to Mobay's tolylene diisocyanate plant at New Martinsville, W. Va., which is being expanded from 40 million to 50 million pounds per year. Completion of the isocyanates unit is expected early next year.

Continental Carbon Co. has started operations at its new $4-million carbon black plant, Bakersfield, Calif. Claimed to be the first of its kind on the West Coast, the installation has a 50-million-pound-per-year capacity of oil furnace black.

American Cyanamid Co. will add about 40 percent to its anhydrous ammonia capacity at Fortier, La., at a cost of $3 million. The chemical complex is near New Orleans. Completion of the expansion is scheduled for late 1962.

Escambia Chemical Co. has let a contract to Chemical Construction Corp. for the construction of a 50-ton-per-day urea solution plant at Pensacola, Fla. The company is also expanding its ammonia capacity from 200 tons to 230 tons daily, and methanol capacity from 16 million gallons to 22 million gallons yearly.

Texaco, Inc., will install new hydrotreating facilities at its Los Angeles refinery at a cost of $5-6 million. The process, designed by Texaco, will test some new ideas in hydrogen treating. Unit capacity is set at 12,000 bpd.

Allied Chemical Corp. will construct a tolylene diisocyanate plant in California to produce 15 million pounds per year. To be completed in 1962, the facility will be expanded to 25 million pounds yearly as demand develops. Site for the plant has not been selected.

Oronite Division of California Chemical Co, a subsidiary of Standard Oil Co. of California, will build a new plant on the East Coast to manufacture phthalic anhydride. The new plant, with an annual capacity of 30 million pounds of phthalic an-

THE QUESTION:

We are operating our present tower, packed with ceramic raschig rings to the full limit of its capacity. Liquid rate is 2500 lbs./sq. ft./hr., and the gas rate is 1000 lbs./sq. ft./hr. If we replace the 1" ceramic raschig rings with 1" Intalox saddles, what increase in capacity can we reasonably expect to obtain?

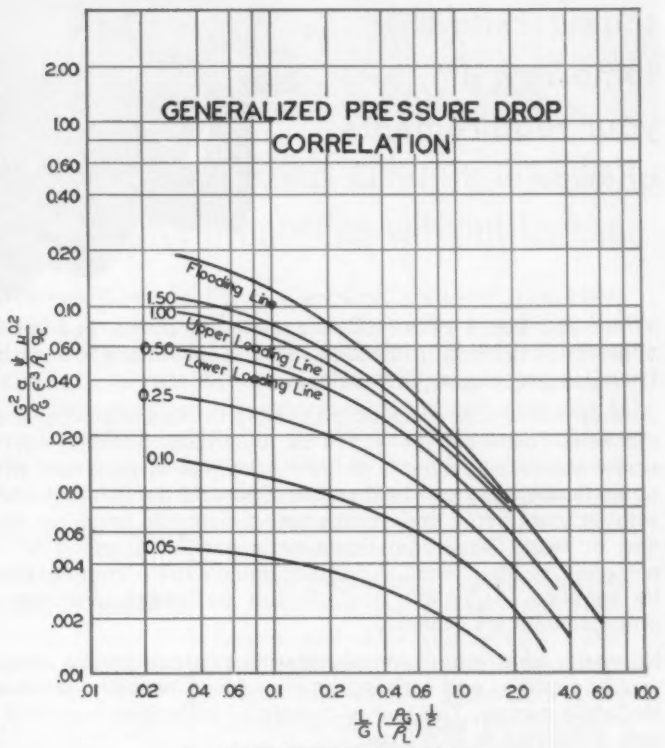
In these days of high equipment costs, wise management looks for ways to increase the output of existing equipment. Questions similar to this one are among the most frequently presented to U. S. Stoneware engineers.

THE ANSWER:

This question can be readily answered by the use of the packing factor chart (GR-122R-1) and the Generalized Pressure Drop Correlation (GR-109R-3) curves taken from U. S. Stoneware's Engineering Manual on Packed Towers.

Inspection of the variables on the ordinate of the Generalized Pressure Drop Correlation shows that the gas rate is inversely proportional to the square root of the packing factor. Reference to the packing factor chart shows that the packing factor, α/ϵ^3 for 1" raschig rings is 160 and for Intalox saddles is 98. Therefore, the increase in capacity which could be expected would be equal to $\left(\frac{160}{98}\right)^{1/2}$ or 28%.

46-H



L = LIQUID RATE, LBS./SEC., SQ. FT.
G = GAS RATE, LBS./SEC., SQ. FT.
ρ_L = LIQUID DENSITY, LBS./CU. FT.
ρ_G = GAS DENSITY, LBS./CU. FT.
α/ϵ^3 = PACKING FACTOR $\approx F_p$
μ = VISCOSITY OF LIQUID, CENTIPOISE
ψ = RATIO, $\frac{\text{DENSITY OF WATER}}{\text{DENSITY OF LIQUID}}$
g_c = GRAVITATIONAL CONVERSION FACTOR = 32.2

The data appearing in U. S. Stoneware's ENGINEERING MANUAL ON PACKED TOWERS offers ready answers to this and countless other questions on packed tower performance. If you would like a copy for your personal or company use, please write us on your letterhead.

Process Equipment Division

U. S. STONEWARE
AKRON 9, OHIO

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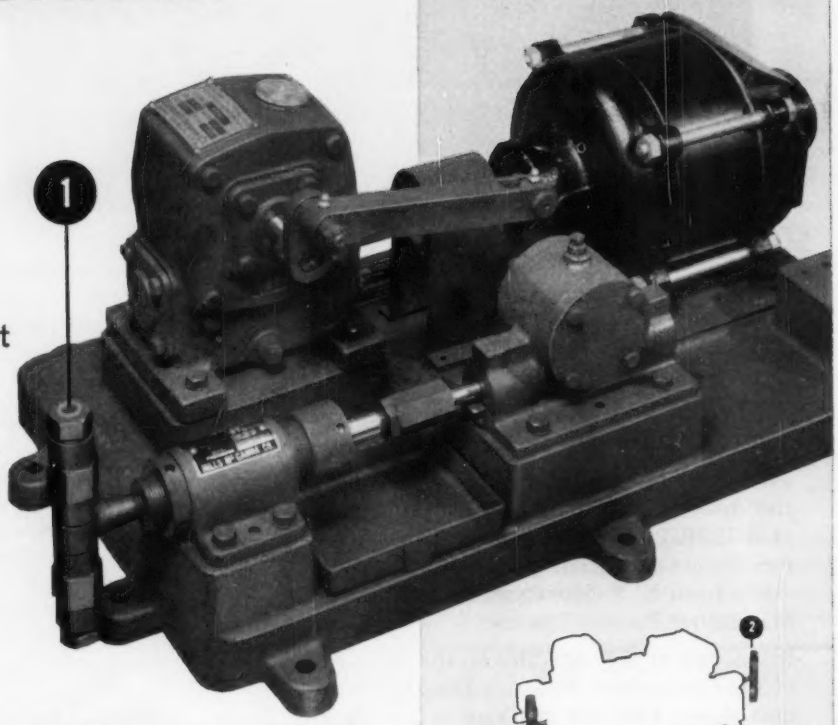
Add-on

Metering Pumps

let you buy only what you need today... add to it tomorrow if your requirements change

Hills-McCanna Model "U" pump, single feed



. . . a second feed can be added to a pump with a two-feed base

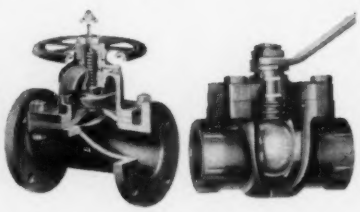
. . . or a second, third, or fourth feed can be added to a pump by using a four-feed base

When you buy a Hills-McCanna metering pump, you are buying appreciable built-in protection against obsolescence caused by changing process requirements.

Add-on construction makes it possible to modify pumps already in the field. Feeds can be added as illustrated. Optional micrometer screw stroke adjustments to permit change in feed rate while the pump is operating can be installed. Standard heads can be replaced with jacketed liquid ends for pumping materials requiring refrigeration or heat. Diaphragm liquid ends can be supplied to replace plunger-type liquid ends. All-plastic liquid ends (Penton or PVC) can be supplied. Automatic controls can be added. Variable speed arrangements are available.

No matter what your chemical metering or proportioning application, you'll be money and satisfaction ahead with versatile, reliable Hills-McCanna pumps. The line is complete—capacities from 0.10 to 980 gph, pressures to 30,000 psi.

For specific recommendations, write today for literature, outlining your particular requirements.



Hills-McCanna also manufactures a complete line of diaphragm valves 1/2"-16"; ball valves 1/4"-12"; and magnesium alloy castings.

Optional micrometer screw stroke adjustment can be added at any time

HILLS-McCANNA COMPANY

400 MAPLE AVENUE • CARPENTERSVILLE, ILLINOIS

Building . . .

hydride, will be built at the California Oil refinery in Perth Amboy, N. J. The feed stock for phthalic anhydride is orthoxylene. A major expansion of the chemical complex at Richmond is currently underway which will increase the output of orthoxylene to more than 100 million pounds.

Mobil Oil Co. has completed a 20,000-bpd delayed coking unit at its Beaumont, Texas, refinery, boosting the company's total coke-making capacity to 3,300 tons per day. The Beaumont unit produces up to 800 tons of coke per day, at the same time converting heavy fuels and residues into gasolines, light fuel oil and petroleum gases.

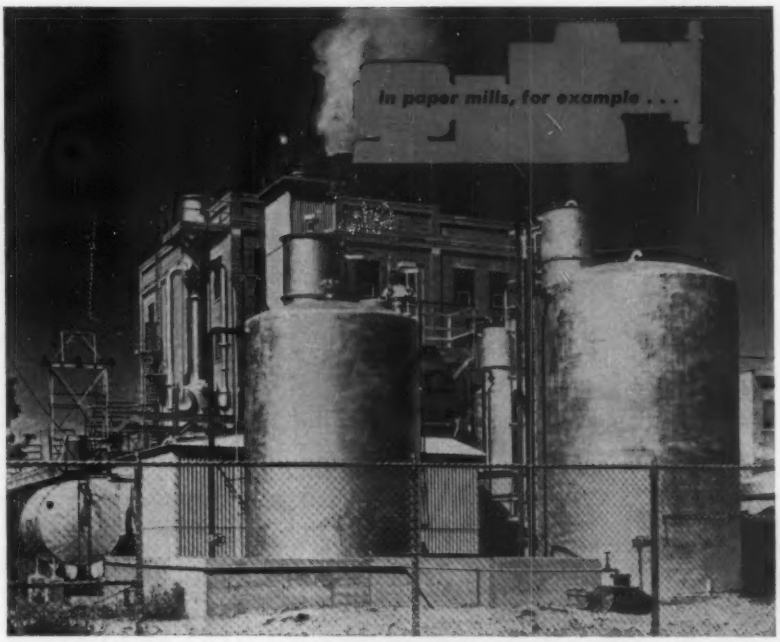
Pennsalt Chemicals Corp. will nearly double the capacity of its alkyl amines unit at Wyandotte, Mich. Work on the expansion is now underway and will be completed in early 1962. The $2-million project will increase Pennsalt's ability to supply ethylamines, isopropylamines and butylamines.

National Starch and Chemical Corp. will build a plant to produce 45 million pounds per year of vinyl acetate compounds. The $4-million facility will probably be somewhere on the Texas Gulf Coast, where the company has two sites optioned.

Hudson Gas & Oil Corp. expects to complete its cold-absorption gas processing plant in Jefferson County, Texas, by early fall. The $5-million facility, which is being constructed by Early Co., Shreveport, La., will have a 150-MMcfd capacity of gas. The plant will be owned by Port Gas Processing Co., a subsidiary of Hudson. Products from the unit have been sold to Tuloma Gas Products Co., Tulsa, Okla.

Texaco, Inc., will construct a 28,000-bpd delayed coking unit at its Lockport, Ill., refinery. Construction has begun and the new unit is planned to go into operation in mid-1962. The contract for design, engineering and construction has been awarded to Foster Wheeler Corp.

Monsanto Chemical Co. has begun operation at Long Beach, Calif., of a



Pulsafeeder compounds chlorine dioxide bleach in perfect proportion without leakage

For Nekoosa-Edwards Paper Company, a special quintuplex Pulsafeeder provides continuous production of a bleaching compound that is too unstable to store. Each of the five heads is independently adjustable to meter out the proper proportion of water, sodium chlorate, sulphuric acid, and two additions of methanol. Result: a critically precise formulation of chlorine dioxide, with total output controlled by a single variable speed drive to keep pace with process rate. Never a drop of leakage . . . never a trace of corrosion . . . in over four years of steady use!

PULSAFEEDER IS THE METERING PUMP THAT:

withstands the hardest-to-handle materials you can feed into it . . .

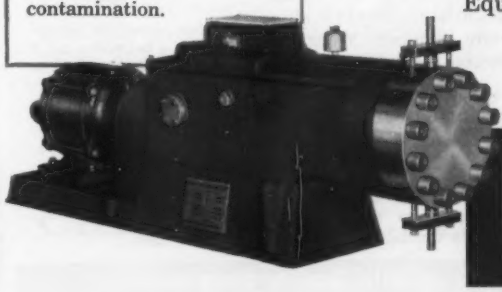
meters them at critically controlled flow rates . . .

never leaks a drop . . .

and completely seals pumping fluids from process materials so there can never be a trace of contamination.

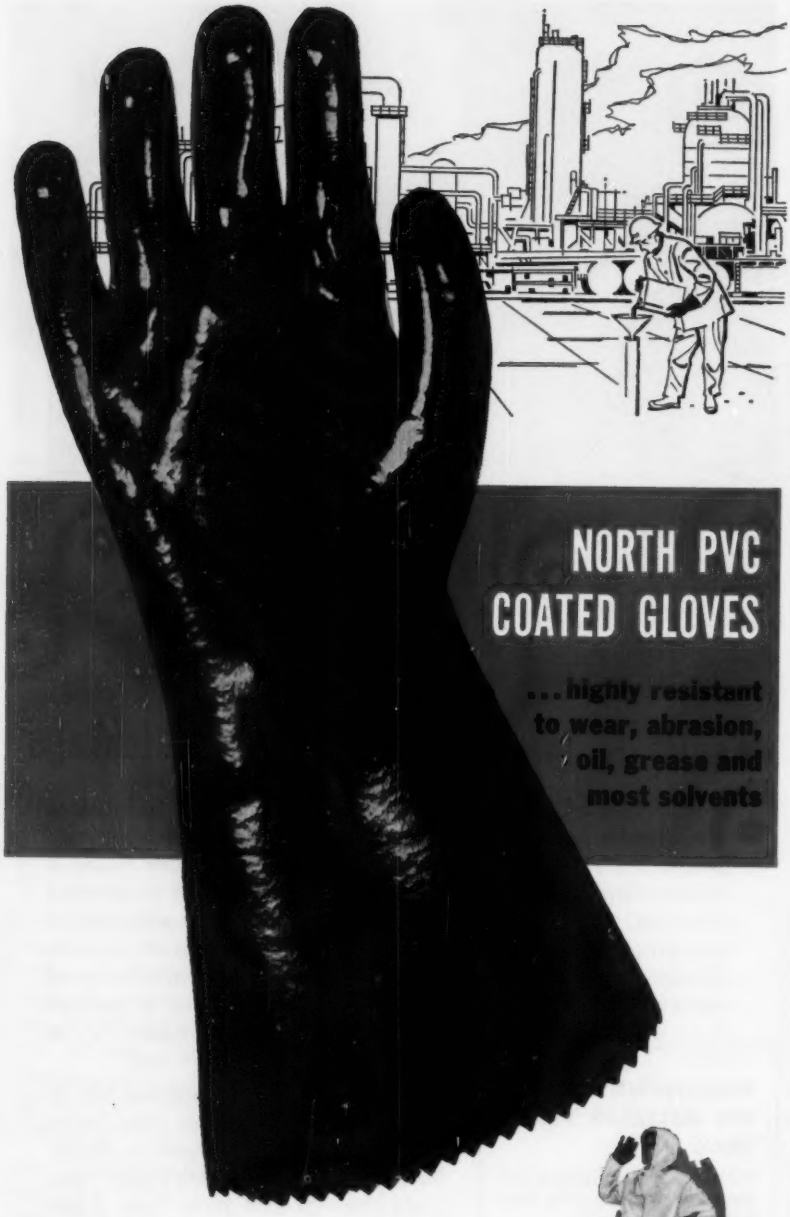
The harder your materials are to handle, and the tighter your tolerances, the more you need a Pulsafeeder. Choose from today's most complete line—in flow rates from a few drops to 15.7 gallons per minute—with reagent heads resistant to any material you use.

WRITE for Catalog 59. Lapp Insulator Co., Inc. Process Equipment Division, 1521 Poplar Street, LeRoy, New York.



Lapp

For more data on advertised products, use cards, last page.



NORTH PVC COATED GLOVES

...highly resistant to wear, abrasion, oil, grease and most solvents

Uniform polyvinyl chloride coating over thin liner offers longer service and superior protection against oil, grease, most acids, solvents and other chemicals. Coating is flame resistant and nonoxidizing, will not crack or peel, is extremely flexible. Thin liner absorbs less water, permits easier laundering. Gloves are shaped and sized to fit the hand, thus providing greater dexterity, more comfort. Write for complete information and literature.

WRITE TODAY FOR LITERATURE DESCRIBING THESE PROTECTIVE PRODUCTS BY JOMAC

To keep workers dry and comfortable in foul weather and to give them superior protection against chemicals, oils and greases—insist on North PVC Protective Clothing.

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"Jomac Sells Quality . . . and Quality Sells Jomac!"

Building . . .

unit to produce about 15 million pounds per year of phthalate esters. It is the company's third manufacturing unit for phthalate esters, supplementing plants for these products at St. Louis, Mo., and at Everett, Mass. A fourth production unit now is under construction in the Delaware River Valley at Monsanto, N. J., with start-up scheduled for early 1962.

Standard Oil Co. of California has selected Pascagoula, Jackson County, Mississippi, as the site for a proposed 100,000-bpd refinery to supply Standard Oil Co. (Kentucky) with its product requirements. Facilities proposed for the refinery include a 17,000-bpd plant for Isocracking.

Hercules Powder Co. has started building two facilities at Louisiana, Mo., to produce ammonium nitrate and ammoniated ammonium nitrate. Capacity for ammonium nitrate will be 50,000 tons per year. Both agricultural chemical units will be on stream in one year.

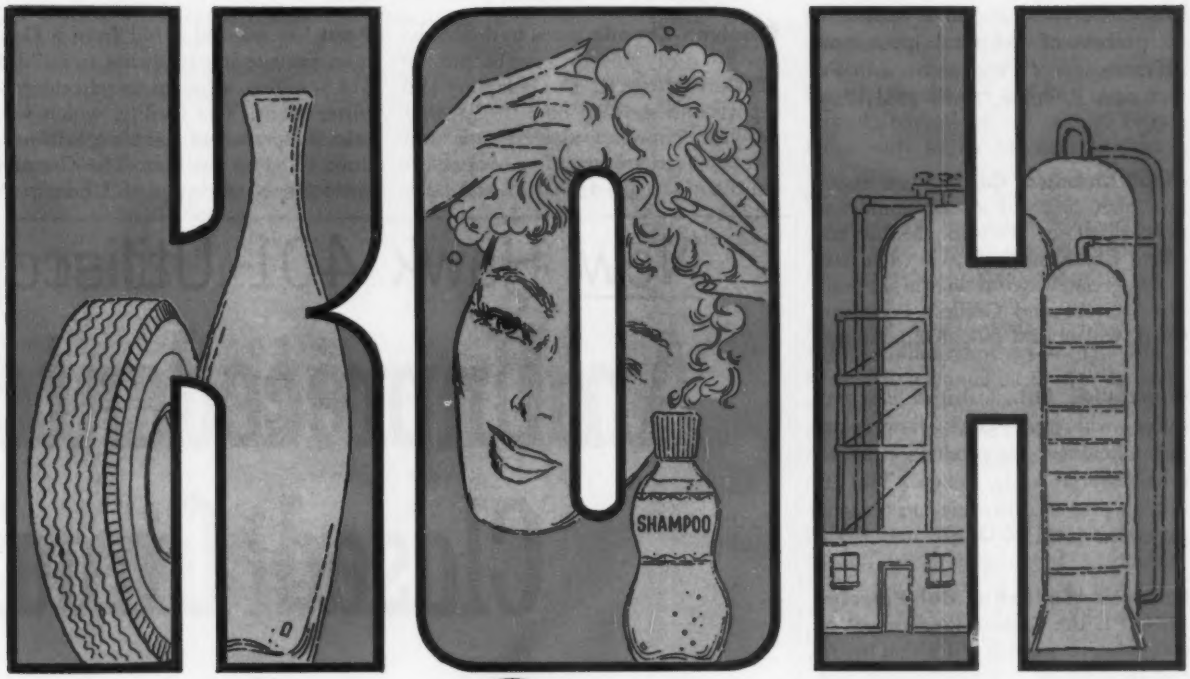
Crown Central Petroleum Corp. has placed a 17-million-gallon benzene plant on stream at its refinery near Houston. The unit, engineered by Houdry Process Corp., is producing high yields of better than nitration-grade benzene by the hydrodealkylaton of toluene. Catalytic Construction Co. handled detailed engineering and construction.

Phillips Petroleum Co. has started operations at its new benzene plant in Sweeny, Texas. The company has also begun manufacturing carbon black at a new plant at Ravenna, Italy. This facility is 50 percent owned by an Italian firm.

British Petroleum Co., Ltd.'s German subsidiary reports that its planned Bavarian refinery probably will take six to eight years to complete. However, if the Bavarian demand increases, completion may be sooner. Other refineries to be built in the area by 1964 include those of Esso Petroleum Co., Shell Oil Co., Italian ENI and possibly Gelsenberg Benzin A.G.

The Ohio Oil Co. has set up Cia. Iberica Refinadora de Petroleos S.A.

Alkali users who depend on



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Building . . .

to handle its 24,000-bpd refinery venture in Northwest Spain. The Spanish firm is initially capitalized at $12.5 million with option for an increase to $18.8 million. Ohio Oil is furnishing 84 percent of the total investment. (HYDROCARBON PROCESSING AND PETROLEUM REFINER, April 1961, Page 200.)

Mobil Chemical Co. and two associates plan to build an ammonia and urea plant in Taiwan. Mobil and Allied Chemical Corp. will each have a 35-percent interest in the $24-million venture and Chinese Petroleum Corp. will hold a 30-percent interest.

Courtaulds, Ltd., a British fiber producer, will supply know-how, plant and machinery for production of acrylic fibers at Lodz, Poland. The $6-million project is expected to be completed in 1963.

Empresa Nacional del Petroleo (ENAP), the Chilean government oil company, may reach a decision by the end of 1961 on a long-standing plan for a second refinery to meet the anticipated 1964-65 demand growth. ENAP's present refinery at Concon has been doubled to 44,000 bpd. The new plant will probably be located in the Conception area. Proposed capacity for the plant has not been revealed.

The Firestone Tire & Rubber Co. will operate a new polybutadiene rubber plant to be constructed at Recife, Brazil, as part of the industrial development of Northeastern Brazil. The plant will have an annual capacity of 30,318 tons.

Construction will begin this fall and it is expected to be completed in approximately two years. The facility will be the first of its kind in South America.

This will be the third plant in which Firestone will manufacture polybutadiene. A plant at Orange, Texas, went on stream last spring with an annual capacity of 30,000 long tons, and production is scheduled to begin in a new plant at Port Jerome, France, late this year. Lummus Co. of New York will build the Recife plant.

Iraq is planning to build an ammonium sulfate plant near Basra to provide over 17,000 tons. The facility, which will use Soviet-developed processes, will also turn out 55,125 tons of ammonium nitrate and over 22,000 tons of sulfuric acid annually.

Scholven-Chemie plans to double its low-pressure polyethylene output to 12,000 tons yearly. The company also reports the start-up of a 10,300-ton-per-year isopropyl alcohol unit and the proposed construction of a resorcin plant to make 4,000 tons annually.

Ruhroel Chemiewerk der Steinholenbergwerke Mathias Stinnes, a West German concern, has plans to increase its maleic capacity to 4,000 tons per year and its fumaric acid production to 3,000 tons from 2,400 tons.

Peru has selected a bid from a German engineering syndicate to build a $15.5-million ammonium nitrate fertilizer plant. The facility, which will take three years to complete, will produce 190 tons per day. The German syndicate is made up of Uhde, part

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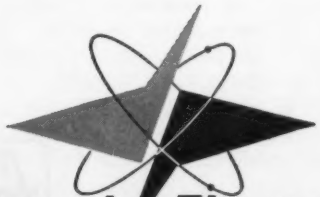

Diamond Electronics

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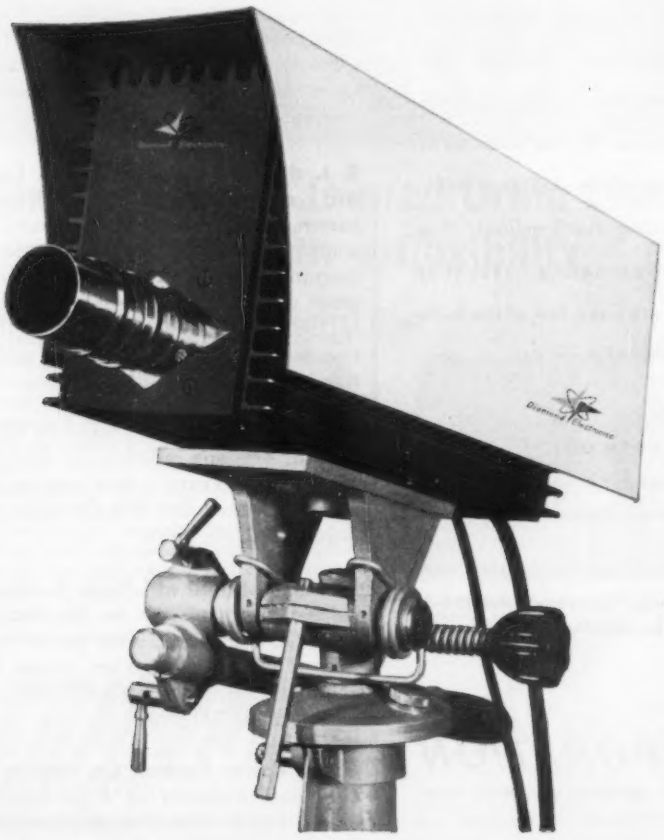
of the Farbwerke Hoechst A.G. group; Ferrostaal, of the Gutehoffnungeshuette engineering complex; and Hochtief, a construction company.

Steelman Gas Co., Calgary, Alta., is seeking approval from the Alberta Oil & Gas Conservation Board to build a $1.6-million gasoline plant. The proposed facility would have a 70,000-Mcfd capacity.

Thailand's cabinet has accepted two refinery proposals—one from Phillips Petroleum Corp. and one from Thai Oil Refinery Co. Phillip's bid to construct a 30,000-bpd plant was submitted by Summit Industrial Corp., New York. Thai Oil Refinery, who will receive part of its crude requirements from Shell Oil Co., proposes building a 40,000-bpd plant. Thai Oil Refinery has government officials on its board of directors. Seven bids were submitted to the Thai government for refineries. One proposal stipulation is that government take over plant in 10 years.

permits...

Proposition In Television...



Petrocarbon Developments, Ltd., will build a polystyrene plant in Rumania. To be completed by the end of 1962, the facility will cost about $2.24 million. Last year Petrocarbon handled engineering of a polystyrene unit for Poland. The Rumanian project is part of the Anglo Rumanian trade agreement.

British American Oil Co. Ltd., has started operations of a 7,000-bpd Udex unit at its Montreal refinery. The unit was designed and licensed by Universal Oil Products Co. The plant takes its aromatics-rich feed stock from British American's catalytic reforming installation.

Polymer Corp., Ltd., has awarded a $1.5-million contract to The Fluor Corp. of Canada, Ltd., to handle engineering, purchasing and construction of a butadiene extraction unit at Sarnia, Ont. Completion is set for fall 1961.

North Star Oil, Ltd., has started operation of a combined Unifining-Platforming unit at its St. Boniface, Man., refinery. The 2,700-bpd installation was designed by Universal Oil Products Co. and constructed by Procon (Canada), Ltd., Toronto. Feed is a 180-385° F stock fractionated from Alberta and Saskatchewan crudes.

Societe de La Raffierie de Strasbourg has selected PIC Engineering to build an atmospheric distillation unit and gasoline treating unit at its Strasbourg, West Germany, refinery. McKee-Head Wrightson of London will provide process design, basic mechanical design and general supervision. The unit, designed to process 3.3-million tons annually of Hassi-Messaoud and Iraq crude, is scheduled for completion by early 1963.

Continental Oil Co. and National Bulk Carriers have made a proposal to the El Salvadoran government for construction of a $6-million ammonia plant at Acajutla.

Nippon Mining Co. has placed a Houdriformer unit on stream at its Mizushima, Japan, refinery. Licensed and designed by Houdry Process Corp., the unit produces 6,000 bpd of petroleum naphtha. The facility also has a pre-treater which also handles the desulfurization of naphtha to be used in jet plane fuel. Engineering was by

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Building . . .

Houdry and Catalytic Construction Co. Nissho Co., Ltd., and Niigata Engineering Co., Ltd., handled construction.

Istanbul Petrol Rafinerisi A.S. (IPRAS) has placed a 20,000-bpd refinery on stream at Izmit, Turkey. IPRAS is owned by Caltex and Turkish Petroleum Co. Caltex, who will supply the plant's crude requirements, will operate the facility for 14 years, after which it will sell out to Turkish Petroleum, a government oil company.

Esso A.G. has decided to build its planned Bavarian refinery by early 1964 with 70,000-bpd capacity instead of originally planned 40,000-bpd. Esso A.G. has made a processing agreement with British Petroleum Co., Ltd.'s German affiliate. Esso Research and Engineering Co. is handling design and engineering.

Hunt International Petroleum Co. is pushing ahead its plans for a 15,000-bpd refinery at Monrovia, Liberia. The company's 25-year monopoly refining agreement ratification is on the Liberian legislature's agenda for October 15. Hudson Engineering Corp. of Houston is currently doing preliminary work.

E. I. du Pont de Nemours & Co., Inc., and Etablissements Kuhlmann, Paris, France, have formed a company, Dekachimie, to produce isocyanates in France. A $6-million plant is expected to begin production in 1963. Kuhlmann will provide the raw materials for the plant in addition to its site.

Amoco Australia will build its $24-million Brisbane refinery at Bulwer Island. The state government of Queensland requires that the plant be finished by late 1965.

Deutsche Shell will begin building its Bavarian refinery at Ingolstadt, West Germany, before the end of the year. The plant, to go on stream in January 1964, will have an initial capacity of 40,000 bpd.

Great Lakes Carbon Co. will be a U.S. collaborator in a privately owned Indian venture to produce cal-

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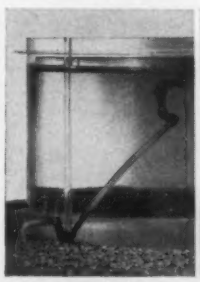

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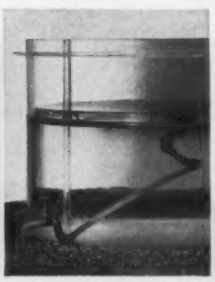

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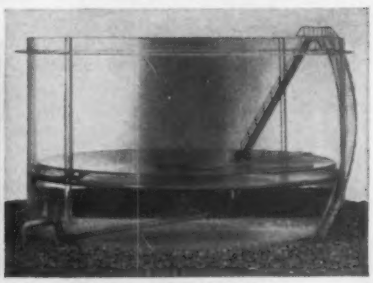

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Building . . .

cined petroleum coke and calcined anthracite coal. The Indian company involved is receiving a loan from the Export-Import Bank. Great Lakes is expected to own 40 percent of the project.

Dominican Republic is the site of a proposed $12-million refinery and fertilizer plant to be built by Thomas Pappas, Boston businessman. Another proposal for a 12,000-bpd refinery in the country has been submitted by a French group as an outlet for Sahara crude.

Canadian Kodiak Refineries, Ltd., Edmonton, Alta., has started building a 2,000-3,000-bpd refinery at The Pas, in Northwestern Manitoba. The $4.5-million plant will turn out premium and regular gasolines, jet fuel, diesel and fuel oil, resid and asphalt. The facility, which is set to go on stream this year, will run crude from Saskatchewan and Southwestern Manitoba.

Tanganyika has received an offer from Ente Nazionale Idrocarburi, the Italian state-owned oil company, to construct a refinery at Dar-es-Salaam. The government will have an option of a 50-percent interest. Caltex and Standard Vacuum Oil Co. are also interested in building refineries in Tanganyika.

Imperial Chemical Industries, Ltd., will begin its petrochemical construction program in Rotterdam, the Netherlands, with an acrylic products plant. The 10-year investment plan for continental Europe is expected to cost $280 million before it's finished.

The Dow Chemical Co. plans to construct a petrochemicals plant in Spain to produce 10,000 tons of high-pressure polyethylene, 6,000 tons of low-pressure polyethylene, 8,000 tons of polypropylene and 12,000 tons of styrene annually. The plant, to be located at Somorrostro, near Bilbao, should be completed by early 1963.

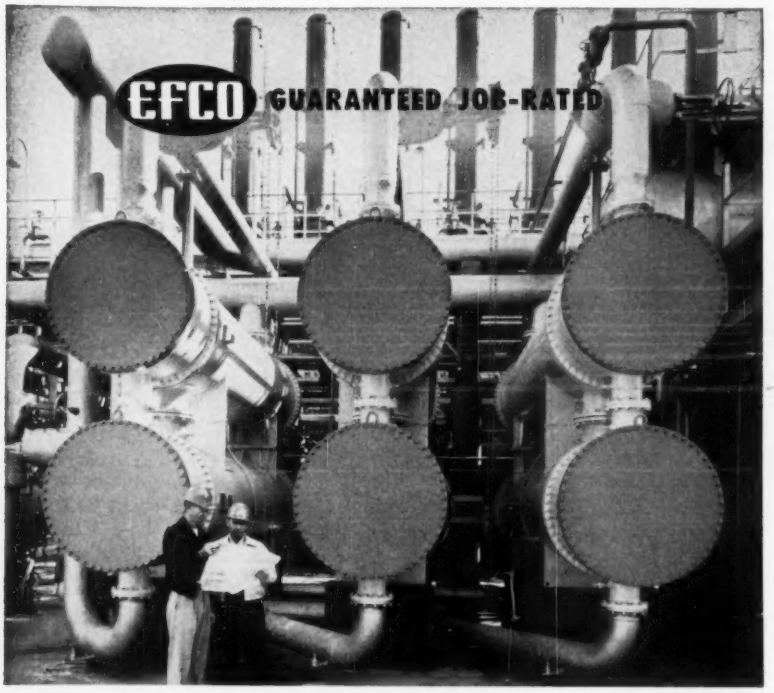
Esso Nederland plans to construct a lube oil plant and aromatic raw materials unit at its Rotterdam refinery. The lube unit, to go on stream before January 1963, will have a 35,000-ton annual capacity. The aromatics facility will start producing in early 1963 with initial annual capacity at 220,000 tons. Total cost for both units is over $20 million.

Dansk Veedol, subsidiary of Tidewater Oil Co., has completed a 20,000-bpd refinery at Kalundborg, Denmark, 60 miles west of Copenhagen. The plant cost $20 million.

Gewerkschaft Erdol-Raffinerie Emsland plans to expand its Lingen, West Germany, refinery from 2.5 million to 3 million tons annually.

British American Oil Co. has completed a $2.5-million aromatics extraction plant at its Montreal East refinery. The plant, having a 6-million-gallon-per-year capacity of benzene, was built by Foster Wheeler, Ltd. The benzene produced is used in B-A's cumene operation.

Israel's government has approved the construction of an oil refinery at the Red Sea port of Eilat. The plant, which will supply ships and provide fuel for development projects in the Negev Desert, will have a 50,000-ton output yearly.



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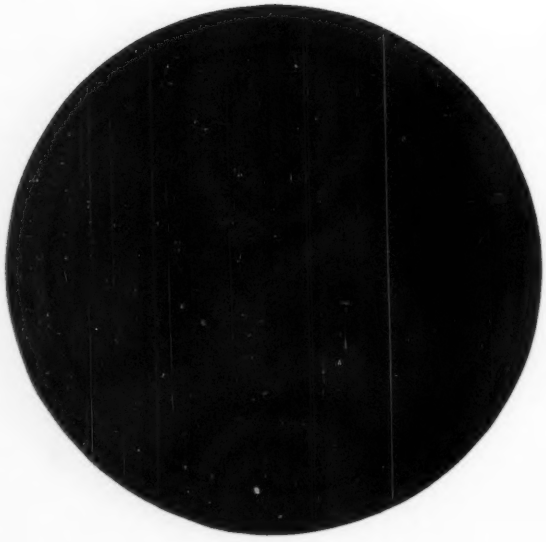
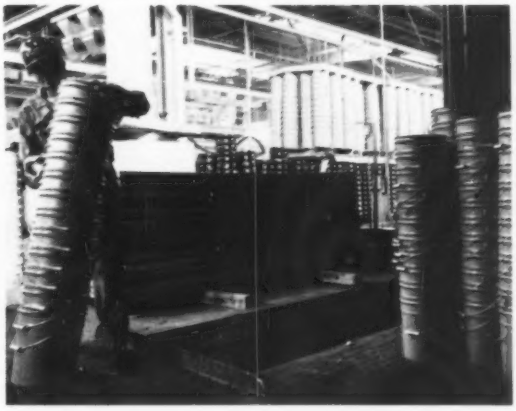


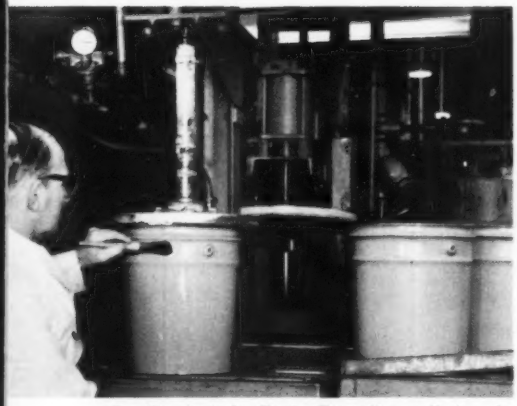
This is the new U.S. Steel nesting pail... the Taper·ite

The U. S. Steel Taperite is the finest pail to ever hit the packaging field. Look at its design. Notice there is a top swedge in addition to a bead. This makes the Taperite pail stronger. And the lower bead is the only contact point when the pails are nested. The single side seam is welded and each pail is air tested for tightness. ☐ Notice the embossed design of the Taperite cover. When filled pails are stacked and rolled — the embossment makes a tight and secure fit. And the cover is standard size, so regular closing tools can be used. ☐ Taperite pails offer real economy too — they save storage space and expensive handling time. What could be more practical? ☐ For further information and samples of the Taperite pail, wire, write or call your nearest U. S. Steel Products Division representative.

Saves 66⅔ storage space: Taperite's nesting feature saves you ⅔ the space needed for conventional pails.

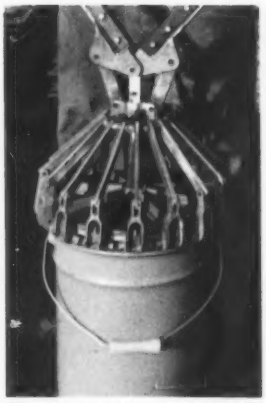
Below—*Cuts handling costs:* Unloading and handling time are cut down because more pails can be handled at the same time. Cuts the hazard of stacks falling during shipment or in handling.





Quality tested: Each Taperite pail is air-tested for tightness and visually inspected before we ship it. Taperite pails are also subjected to drop tests, hydrostatic tests and vacuum tests on a periodic basis.

Right—*Easy stacking:* The double seamed bottom fits the special debossment in the cover permitting easy stacking and handling when the pails are filled.



Regular equipment can be used: The top of the Taperite pail is the same size as a standard pail so Taperite's lug covers can be closed with regular closing equipment.

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These specifications conform with ICC requirements

Capacity in U.S. Gallons	5				6				6 1/2			
Gauge	24	26	28	29	24	26	28	29	24	26	28	29
Approx. Tare Weight W/Cover	5.3	4.0	3.3	3.0	5.9	4.4	3.7	3.3	6.2	4.7	3.9	3.5
Body Height W/O Cover	13 7/8				16 5/16				17 17/32			
Overall Height With Cover	13 31/32				16 13/32				17 5/8			
Outside Diameter Over Bead	12 1/16				12 1/16				12 1/16			
Inside Diameter At Top	11 1/4				11 1/4				11 1/4			
Outside Diameter At Bottom	10 7/16				10 7/16				10 7/16			

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What's Happening

Continued from Page 47

otherwise would be wasted under current practices. Contract, which will result in construction of first of several plants to be built under program, has gone to Helex, subsidiary of Northern Natural Gas, Omaha, Neb. Interior also announced plans to increase wholesale price of helium from $19 to $35 per Mcf to finance helium conservation.

Conoco answers suit

Conoco's answer to anti-trust suit in New Mexico U.S. District Court is that its purchase and lease of Malco Refining Co.'s refining and marketing facilities (those questioned in suit) has tended to increase rather than decrease competition in New Mexico-West Texas area. No tendency to create a monopoly has been shown, says company. Conoco leased Malco refinery at Artesia, N.M., in May 1959, and has since consolidated it with its own refinery there. Conoco claims that business done by them and Malco is small portion of total in area.

Who has export licenses?

Anonymous role enjoyed by firms who sell export licenses is under fire by Chairman John Moss (D-Calif.) of House Government Information Subcommittee. Says Moss: "I will not consider the problem solved until the Commerce Department makes public the names of firms granted export licenses." Commerce Department has agreed to publish all information on export licenses—but no license-holder names. Moss' position: Names should be announced because public has a right to know details of government operation.

Asphalt price fixing

Six asphalt companies were sued in Maine after they had been convicted in a Massachusetts federal court on price fixing charges. Result: Maine has accepted $215,000 settlement on $1.5 million in damages. Koppers and Allied Chemical were only two of six involved in cash settlement. They also agreed to pay about $21,498 to 15 Maine cities and towns to whom they had sold asphalt.

Still two months away

Hearings for House Small Business Committee's investigation of crude oil import program probably won't begin until late October or early November. According to committee aide, "We're still gathering a lot of statistical information; we're not quite ready for hearing stage." Probe by House subcommittee headed by Rep. Steed (D-Okla.) revealed that inland refiners were selling allocations to coastal refiners at $1 to $1.25 per barrel in violation of demand that foreign oil be exchanged for domestic crude. Following four key questions seeking information on these sales were sent to importers:

- In an exchange, if oil was not processed in your own plant but sold, who bought it and who processed it?
- In exchanges of domestic for foreign oils, state each instance in which adjustments were made for any changes in oil prices.
- Your report on exchanges submitted to Oil Import Administration indicated your company would deliver foreign oil at a particular location in U.S. Which firm paid transportation and storage costs? Did you ever take possession of imported oil? If so, give details of facility and location.
- In conclusion and finalizing exchange, have you ever settled any balance by transfer of money? If there were other considerations, give details.

Automation, unemployment

OCAW labor management policies have been praised by Labor Secretary Goldberg for their part in easing impact of technological change in oil industry. Goldberg, speaking before union's annual convention, said: "In few industries has impact of automation been more severely felt than in oil industry, where over last 10 years employment has declined by 20 percent while production has risen more than 50 percent." O. A. Knight, OCAW president, in relating to union's problems of automation and unemployment, stated: "We could establish a principle that a worker could be guaranteed 2,080 hours of work per year. As soon as he had earned the 2,080 hours (overtime included) he would then have leave from employment for balance of that year's time." Knight also asked increase of 50 cents monthly to total of $2.50 in OCAW's per capita tax. Goldberg assured union that Kennedy Administration is working to ease automation problems.

Insurgent OCAW president candidate Norman H. Krieger wants OCAW to merge with other union groups, such as International Chemical Workers, textile and rubber workers. He believes Knight's efforts along these lines have been weak.

Petrochemicals study

A vast study of petrochemical capacity, in both oil and chemical companies is in HPI mill. National Petroleum Council is already analyzing petrochemicals in oil companies, but there is a problem in figuring the role chemical firms play. Reason: Question of jurisdiction between Interior Department (which deals specifically with oil industry) and Commerce Department (which works with chemical industry). Also, chemical industry has no organization like NPC to help with study. Possible result: One of chemical industry's trade associations may handle analysis of 75-100 major petrochemicals produced by chemical companies.

Clean slate in pricing

"If anyone wants to have still another investigation of our prices and our pricing practices, let him come ahead," says Milo I. Hector, Detroit regional manager for Standard Oil Division, American Oil. Hector's statement concerns recent partial restoration of gasoline prices to earlier levels by American and other gasoline suppliers in Detroit area. Talking to Detroit's Common Council, he added, "It has been broadly hinted lately that there must be some collusion on gasoline pricing, that the companies somehow get together and decide

Happenings . . .

what they'll charge. This I flatly, absolutely deny. It is an iron-clad rule in our company that no one can ever discuss prices with a competitor."

Defense seeks help

Oil company help is needed by U.S. Defense Department in updating studies on oil supply picture in event of various hypothetical emergencies. But oil firms are hesitant to assist until they get clearance from Justice Department's anti-trust officials. Assistant Attorney General Lee Loevinger has offered to help Defense Department with its request for U.S. international oil companies to study world oil supply situation.

Buried alive in patents

A backlog of 196,000 patent applications at U.S. Patent Office has government considering plan which would virtually eliminate patents entirely, while keeping potential of enforcing them. How it would work: Applications for patents would be published at certain interval after being filed—but with no prosecution toward issuing patent except where it becomes necessary. This would be combined with "vigorous" expansion of computer programing. Patent jam of 196,000 is more than twice number of 25 years ago.

Who'll make fuels study?

Question still hasn't been answered as to whether special Senate committee will make national fuels policy study. Odds favor that any fuels study will be handled by Senate Interior Committee. A senate bill to force more rigid price regulation on natural gas, has seen no legislative action. It, like other percentage depletion moves, is expected to come up when Congress reconvenes early next year for new legislative session. Latest from Washington: Senate Interior Committee has approved national fuels policy study, but tied it down with small budget.

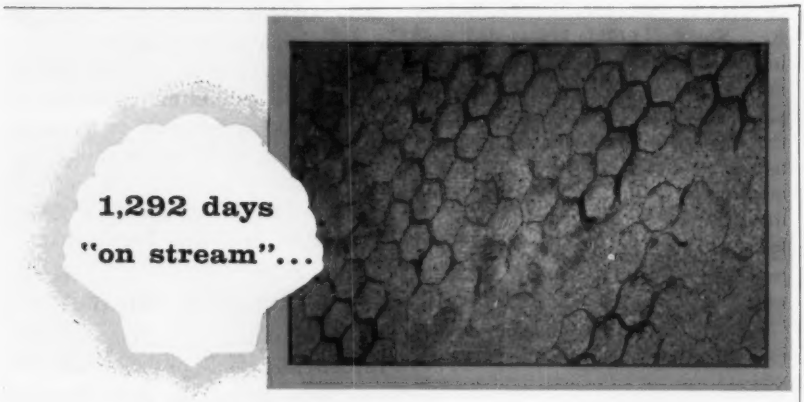
Another point for coal

Another step toward aiding coal industry is seen in Interior Department's recent award of $139,000 contract to find more uses for coal. A leading opponent of residual fuel oil import controls, New England Council, hailed department's action and commented: "At last, we are going to consider ways to find place for coal industry in modern-day America. Government and coal interests have too long tried to solve coal's problems by keeping America back in coal age." Research contract was given to Booz, Allen & Hamilton, Chicago.

- Changing Times -

Hooker Chemical will exercise its option to buy enough stock of new Argentine phenol and monochlorobenzene producer, Duranor, Industries Quimicas Sociedad Anonima Industrial y Comercial, to bring its interests to 50 percent. Other half belongs to major Argentine firm, Atanor, Compania Nacional para la Industria Quimica.

First delivery of a catalytic muffler is made to California Motor Vehicle Pollution Control Board by Universal



in cat cracker at SHELL*

Tough Plibrico Refractories record top-flight performance

Workman gunning Plicast Tuff-Mix on catalyst regenerator wall at Pernis.

Nearly all of Shell's fluid catalyst cracking plants throughout the world use Plibrico linings in the regenerator, cyclons and transfer lines that are supplied and installed by N. V. Plibrico, Rotterdam.

For more than 3½ years, (1,292 days to be exact), Plibrico refractories lining the cat regenerator at Shell's Pernis (Holland) refinery were subjected to continuous scouring action. Despite this, inspection at the end of the period revealed that only minor repairs were needed.

Such outstanding performance is typical of Plibrico products and reflects the scientific knowledge and engineering skills acquired in almost 50 years' service in every field employing refractories.

Plicast Verilite, a lightweight Plibrico castable excelling in insulating properties was used as the insulating component in the No. 2 regenerator. This was faced with a layer of durable, abrasion-resistant Plicast Tuff Mix, applied pneumatically onto stainless hexsteel mesh reinforcing.

WRITE FOR COMPLETE STORY and advantages of Plibrico linings for refinery vessels.

Plibrico

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1812 North Kingsbury Street, Chicago 14, Illinois
Canadian Plant: New Toronto, Ontario
Sales and Service Throughout the World
Since 1914—Pioneers in Refractory Specialties

* SHELL

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Additive buyers respect Norman Schumacher's technical assistance

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Ten years' experience working with additive customers, a degree in mechanical engineering, and a sure knowledge of additive performance are Norman Schumacher's qualifications to provide technical assistance on uses of petroleum additives. These qualifications and the line of AMOCO Petroleum Additives Norm has to offer are the reasons why additive buyers welcome his assistance. Among the additives Norm has to offer are:

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AMOCO 121 barium detergent and AMOCO 193 zinc dialkyl dithiophosphate inhibitor are blended in a wide range of combinations to comprise the AMOCO 200 Series Detergent-Inhibitor additives. They perform six important functions in motor oils: (1) Give high-temperature detergency, (2) Inhibit low-temperature deposit formation, (3) Neutralize acids, (4) Improve viscosity index, (5) Inhibit oxidation and bearing corrosion, (6) Reduce valve-train wear.

Norman Schumacher and other experienced petroleum additive representatives will be glad to tell you more about the AMOCO Petroleum Additives. Call them or use this convenient coupon.

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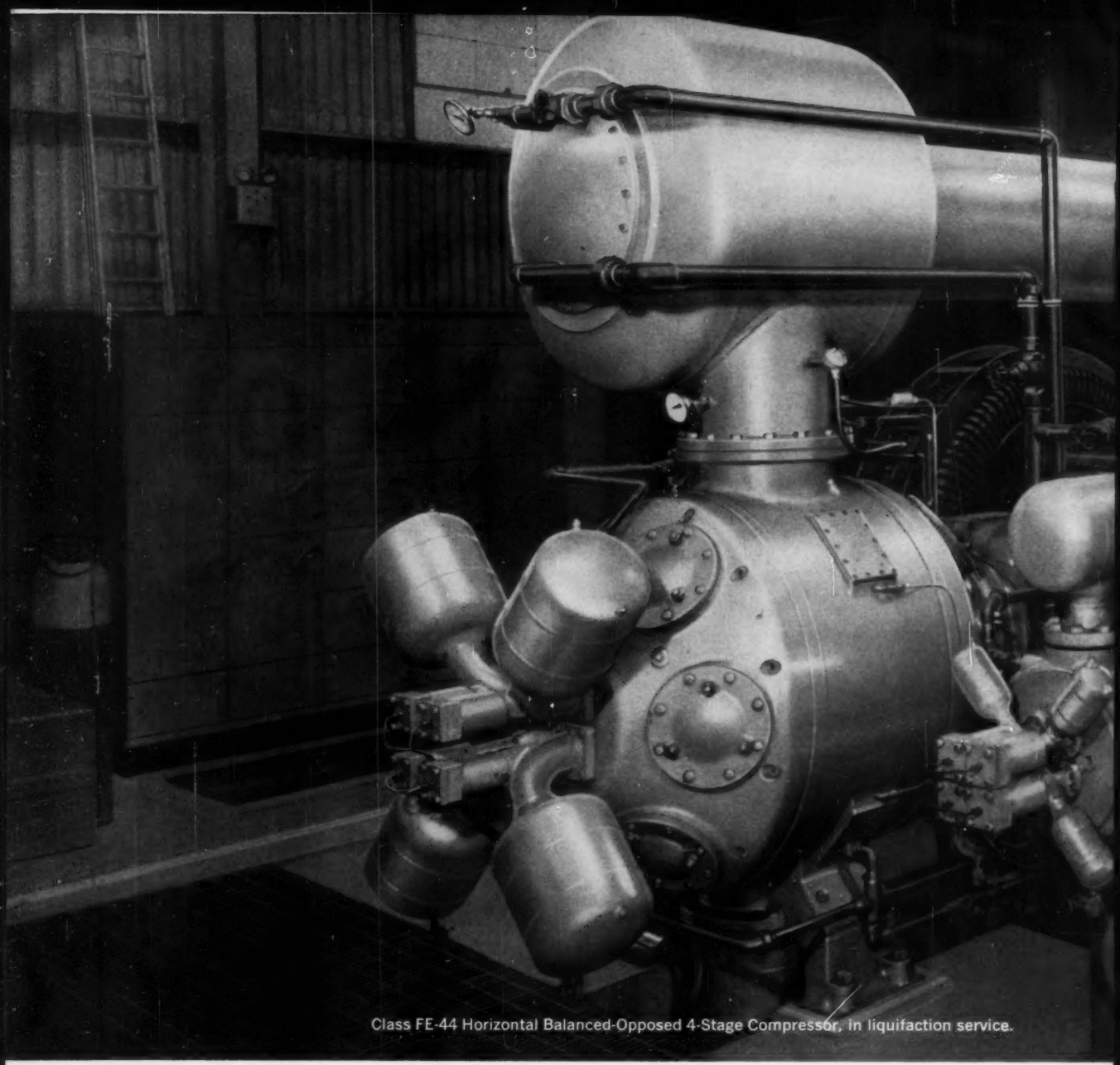


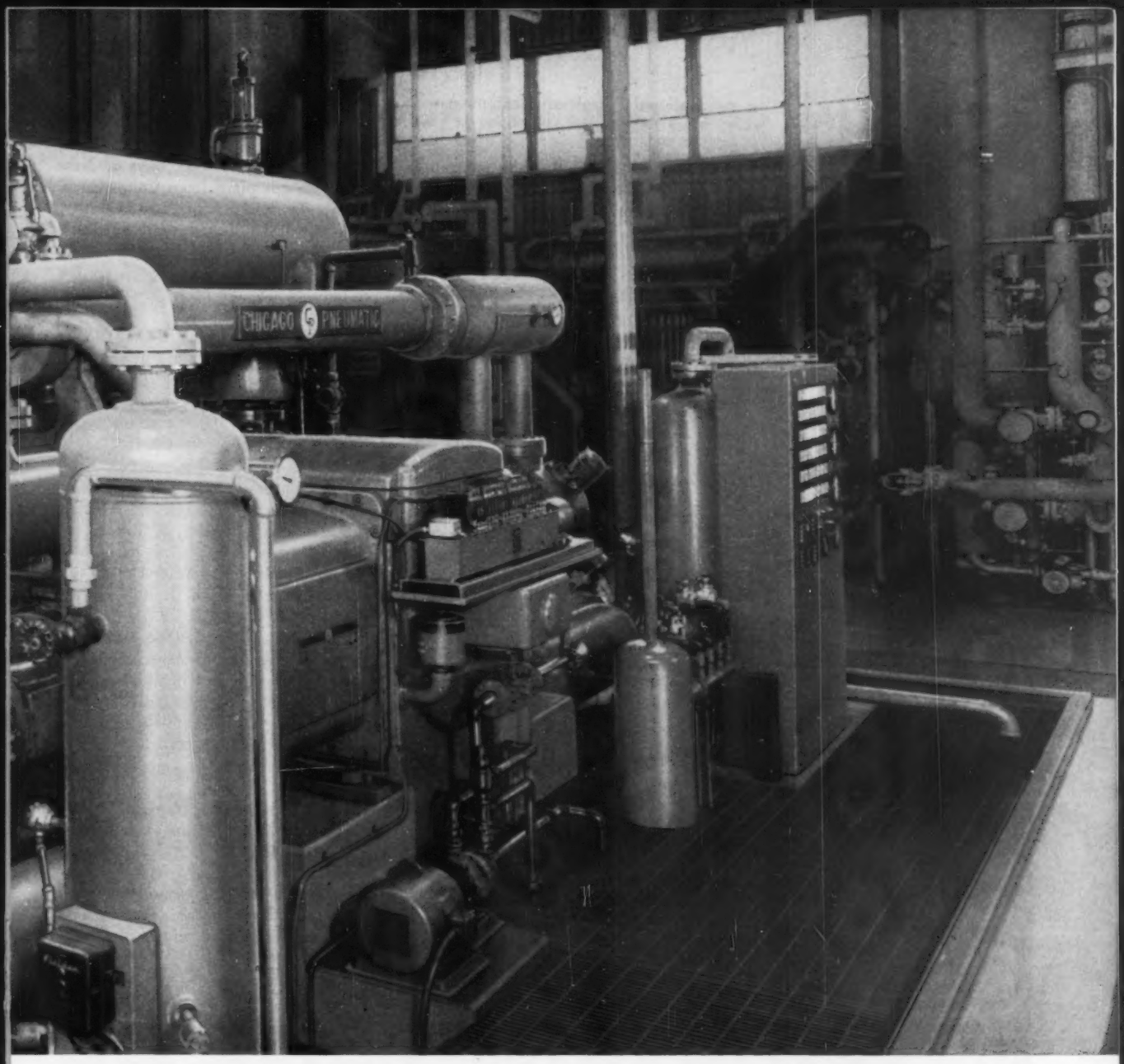
Class FE-44 Horizontal Balanced-Opposed 4-Stage Compressor, in liquifaction service.

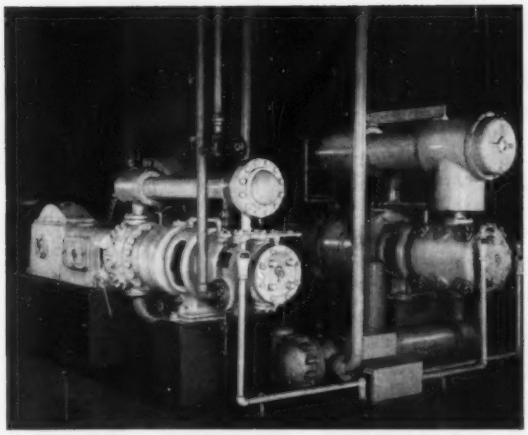
meet all High Pressure Demands with

CP MULTI-STAGE AIR and GAS COMPRESSORS

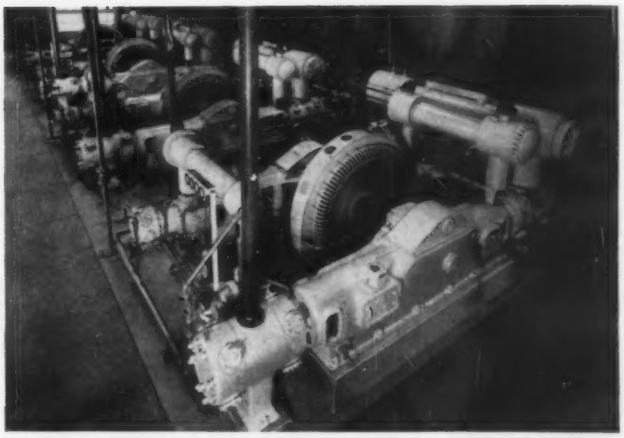
Gas liquifaction and other processes demand compressors that will produce high pressures and take continuous heavy duty in stride. CP Multi-Stage Compressors – Class FE's, H-CE's and O-CE's, for example – are meeting these exacting demands in a wide variety of applications. CP designs for such rigid requirements are available in horsepowers to 5,000, and pressures to 15,000 pounds. Write for detailed specifications.

Chicago Pneumatic 8 East 44th Street, New York 17, N. Y.





Class O-CE Horizontal Duplex, 4-Stage 250 hp Compressor in an oxygen plant.



Class H-CE-5 synchronous motor-driven, 5-Stage Compressors in a chemical plant.

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Changing Times
(continued)

Oxidation Processes. Last February UOP submitted first application, containing required technical data, to be received by Board.

A $2,500 graduate fellowship in field of asphalt technology, first to be set up by National Petroleum Refiners Association (NPRA), is awarded to Purdue University, Lafayette, Ind. It will be known as National Petroleum Refiners Association Fellow.

Union Oil-California is transferring all its Canadian properties and assets to Union Oil-Canada for 2,995,000 shares of latter company. Transaction will bring Union's holdings in its Canadian subsidiary to 3 million shares.

Crude shipments are being made to Indian government refinery under construction at Nunmati from fields in Assam. The crude will be stored for trial runs when plant is completed by end of 1961.

Sinclair Oil & Gas buys a New Mexican gas plant from Cabot Corp. Plant, in King field, Lea County, N.M., will be linked with Sinclair's No. 29 products unit 12 miles to the south. King plant capacity is set for a boost to 6,000 Mcfd by Sinclair.

Employes of Texas Butadiene & Chemical's Lyondell plant near Channelview, Texas, are "rewarded" for a three-year safety record by sharing in company's $6,300 rebate on workmen's compensation insurance.

The Fluor Corp., Ltd., changes name of its New York engineering subsidiary, Singmaster & Breyer, to Fluor-Singmaster & Breyer. Singmaster & Breyer, founded in 1929, became part of Fluor in 1954.

Thirty-two bargaining unit employes transfer from American Oil's refinery to Amoco Chemicals plant, both in Texas City. Amoco Chemicals is expanding work force to man new resin unit being built south of American Oil refinery.

Ingram Oil and Refining and Murphy Corp. merge in an exchange of 440,000 shares of Murphy common stock and $5 million of Murphy preferred stock for all common and preferred stocks of Ingram. Ingram operates a 20,000-bpd refinery at New Orleans.

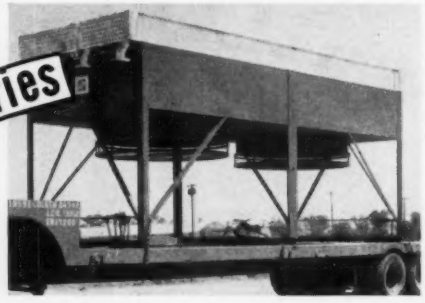
Shell Oil's benzene production for 1961 will exceed 80 million gallons, compared with an estimated industry total of 450 million gallons. Shell claims to be the largest benzene producer in the world.

Nearly 500 U.S. chemical production and laboratory facilities receive Certificates of Safety Achievement from Manufacturing Chemists' Association. The award is presented by the association for operation within preceding calendar year without a disabling injury.

Over 1 billion pounds of lubricants were produced in the United States during 1960. National Lubricating Grease Institute reports this as a gain over 1959. NLGI has distributed totals from its fourth annual production survey to its membership.

another link in Smithco's chain of progress

THE M series
PACKAGED COOLER



Just think how your cooling costs would diminish if you could have a standardized air cooled heat exchanger completely packaged, pre-erected and ready for hook-up upon arrival at your job site. Compared with the cost of a custom field erected unit, the savings in both time and money are clearly evident.

With the advent of the new Mighty "M" from Smithco, field erection costs and delays are completely unnecessary for all small and medium cooling jobs. Even situations requiring high capacity coolers can be handled more economically with two or more "M" series coolers in place of one large custom unit. Here are some other important features of the Mighty "M":

1. *Eliminates custom designing and delays in approving prints.*
2. *Arrives at the site completely erected and ready for electrical hook-up and piping tie-in.*
3. *Standardization of all-welded heavy duty structures permits foundation work and piping layout to begin without delay.*
4. *Easily shipped by truck from factory to your foundation.*

Take a long long look at the Mighty "M" — it's just one more good reason to look to SMITHCO for the solution to your cooling problems.

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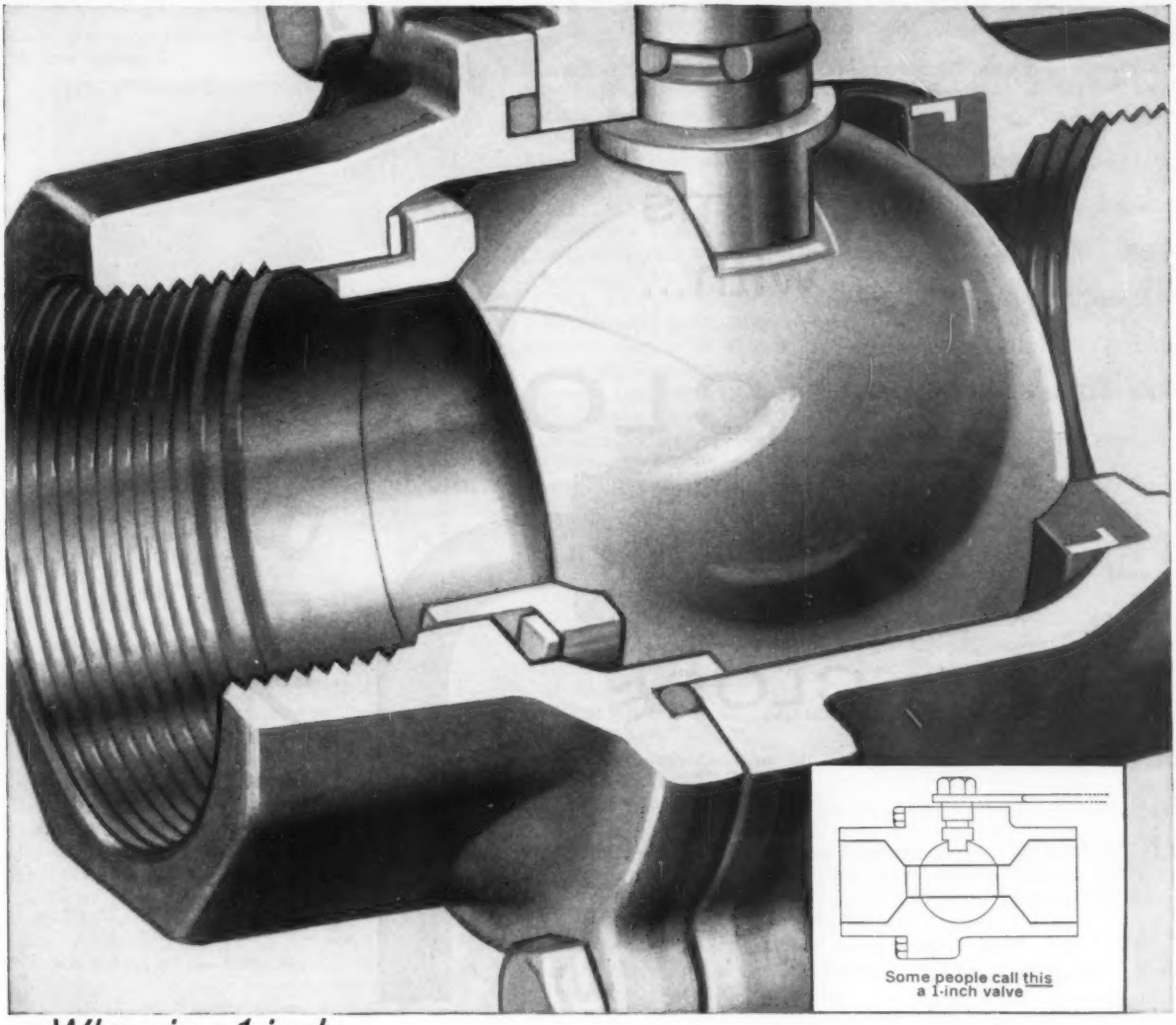
TAKE A CLOSE LOOK AT ROCKWOOD BALL VALVES



When is a 1-inch valve NOT a 1-inch valve?

When the waterway diameter of a ball valve is smaller than the pipe size you can't get perfectly smooth flow. If this difference is large, flow is more turbulent and pressure loss much greater. So it pays to compare waterway sizes before you buy any ball valve. You'll find that Rockwood ball valves have the largest waterway diameters — per given valve size. This means smoother, more economical operation in your line — whether you move liquid, gas or solids.

Rockwood Ball Valves have these other important advantages too.

Ruggedness — durably built for longer service under severe use.

Spring-loaded Ball Seats — compensate for wear, pressure change and temperature effects.

Choice — a wide range of design variations including metal castings of stainless steel, carbon steel or bronze; lever, gear, air, hydraulic or electric operators; standard or top entry types; rubber, Teflon, Kel F or nylon ball seats; flanged, sweat or screw ends — in a full range of pipe sizes from ⅜" to 14".

Reliability — Rockwood ball valves are manufactured by the pioneer in modern ball valve design and are both time- and use-proven in dependable operation and quality of construction.

Why not call in a Rockwood man today? He'll give you the complete Rockwood story. Write Rockwood Sprinkler Company, Ball Valve Department, 255 Harlow Street, Worcester 5, Mass. Distributors in all principal industrial areas. Rockwood Sprinkler Company, A Division of The Gamewell Company, A Subsidiary of E. W. Bliss Company.

ROCKWOOD

BALL VALVES

For more data on advertised products, use cards, last page.

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problems
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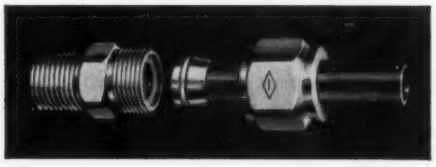
CLOSE BENDS

CLOSE BENDS

With Hi-Seal® fittings you can make tube bends close to the fitting—in fact, right next to it. Here Hi-Seal is in a class by itself.

Hi-Seal's simplified design with flareless butt joint makes this possible. The advantages? More compact layouts. Save on tubing. Shorten installation time by as much as 50%. Gain utmost reliability. SAVE MONEY. To get these advantages, insist on Hi-Seal.

For complete information, write for Bulletin 3108.



BUTT JOINT HI-SEAL

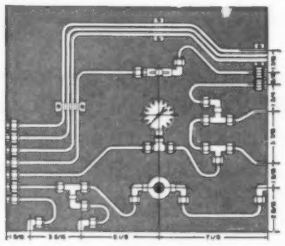
IMPERIAL EASTMAN

Imperial-Eastman Corporation General Offices: 6300 West Howard Street, Chicago 48, Illinois

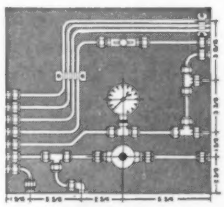
In Canada: Imperial-Eastman Corporation (Canada) Ltd., Barrie, Ontario

Closé Bends with Hi-Seal Save Time, Space, Tubing

Look at what you can do when you use Hi-Seal fittings:



This typical layout has "old-fashioned" tube fittings. Layout area, 257 sq. in.; 12.7 ft. of tubing; *installation time 2 hr., 34 min.*



Same layout with Hi-Seal tube fittings. Layout area reduced 32% to 175 sq. in.; tubing reduced 40% to 7.7 ft.; *installation time reduced nearly 50% to 1 hr., 20 min.!*

All this is possible because of Hi-Seal's exclusive flareless, butt joint design. This means that tube bends may be made right next to the fittings. Even direct tube connections may be made without any extra loops to allow for tube entry into the fitting.

One Fitting for the Entire System

However varied your requirements may be, Hi-Seal meets them. Available in all styles, sizes and combinations, plus a variety of metals: steel, stainless steel, brass, aluminum, titanium, Monel, etc.

Now Imperial-Eastman meets all your requirements for hydraulic-pneumatic-flow system components: tube fittings, valves, couplings, flexible and rigid hydraulic and pneumatic hose, thermoplastic tubing, tubing tools.

FITTINGS

IMPERIAL-EASTMAN

Meetings Calendar

September

11-15.....**Instrument Society of America,** Fall Instrument-Automation Conference, & Exhibit, Biltmore Hotel, Memorial Sports Arena, Los Angeles, Calif.

13-15.....**National Petroleum Refiners Association,** Fall Meeting, Hotel Traymore, Atlantic City, N.J.

-14.....**Natural Gas Processors Association,** Rocky Mountain Regional Meet, Northern Hotel, Billings, Mont.

14-15.....**ASME, AIEE,** Engineering Management Conference, The Roosevelt Hotel, New York City.

18-19.....**Chemical Market Research Association,** Lake George Sagamore, Bolton Landing, N.Y.

20-21.....***NPRA,** Rocky Mountain Regional Technical-Industrial Relations Meeting, Henning Hotel, Casper, Wyo.

24-27.....**American Society of Mechanical Engineers,** Petroleum Mechanical Engineering Conference, Hotel Muehlebach, Kansas City, Mo.

24-27.....**American Institute of Chemical Engineers,** National Meeting, Lake Placid Club, Lake Placid, N.Y.

24-29.....**American Society for Testing Materials,** Committee D-2 on Petroleum Products and Lubricants, Statler Hotel, Detroit, Mich.

25-28.....**American Welding Society,** Fall Meeting, Adolphus Hotel, Dallas, Texas.

October

4- 6.....**ASME, Process Industries Conference,** Shamrock Hilton Hotel, Houston, Texas.

8-12.....**Water Pollution Control Federation,** Milwaukee Auditorium and Schroeder Hotel, Milwaukee, Wis.

10-12.....**American Standards Association,** National Conference on Standards, Rice Hotel, Houston, Texas.

11-12.....***NPRA,** Waste Disposal and Stream Pollution Conference. Hotel Lassen, Wichita, Kan.

12-13.....**California Natural Gasoline Association,** Annual Fall Meeting, Lafayette Hotel, Long Beach, Calif.

-16.....**American Society of Safety Engineers,** Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

23-26.....**National Association of Corrosion Engineers,** South Central Region Conference and Exhibition, Shamrock Hilton Hotel, Houston, Texas.

25-26.....***NPRA,** Annual Question and Answer Session on Refining Technology, Rufus Garrett Hotel, El Dorado, Ark.

-27.....****NGPA,** Southern Regional Meeting, Carlton Hotel, Tyler, Texas.

29- Nov. 1.....**National Lubricating Grease Institute,** Annual Meeting, Rice Hotel, Houston, Texas.

November

9-10.....**Society of Automotive Engineers,** National Fuels & Lubricants Meeting, Shamrock Hilton Hotel, Houston, Texas.

13-15.....**American Petroleum Institute,** Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

-17.....****NGPA,** Panhandle Plains Regional Meeting, Herring Hotel, Amarillo, Texas.

26- Dec. 1.....**ASME,** Winter Annual Meeting, Statler Hilton Hotel, New York, N. Y.

27- Dec. 1.....**Exposition of Chemical Industries,** New York Coliseum, New York, N. Y.

December

3- 6.....**AIChE,** Annual Meeting, Hotel Commodore, New York, N.Y.

5- 6.....***NPRA,** Computer Conference for Refiners, Hotel Tulsa, Tulsa, Okla.

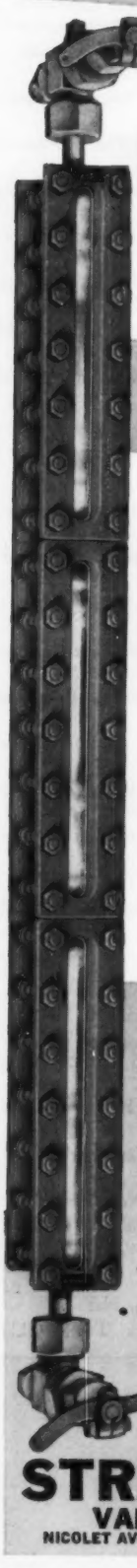
1962

January

8-12.....**SAE,** Annual Meeting, Cobo Hall, Detroit, Mich.

***NPRA—National Petroleum Refiners Association.**
****NGPA—Natural Gas Processors Association.**

Strahman



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- Gauge Cocks

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New Books...

As selected by the editors of HYDROCARBON PROCESSING & PETROLEUM REFINER

Motor Fuel Data

Bridgeman, Oscar, C.; Aldrich, Elizabeth W.; and Legatski, T. W., *Interpretation of Motor Fuel Survey Data,* Natural Gas Processors Association (formerly Natural Gasoline Association of America), 421 Kennedy Building, Tulsa, Okla., 183 pages, $3.

Based largely on motor fuel survey data, the new book analyzes engine performances as affected by fuel volatility, develops performance ratings for motor fuels, and plans a system performance uniformity in all seasons and localities.

Petroleum Products

Quality Assessment of Petroleum Products, The Institute of Petroleum, 61 New Cavendish St., London, W.1, England, 123 pages, $2.30.

The influence of the properties of petroleum products on their performance and on the interpretation of the results of standard tests. Supplements the annually issued volumes of test methods of the IP.

Engineering Colleges

Bryant, Paul T.; Penn, John F., editors, *Engineering College Research Review—1961,* Engineering College Research Council of the American Society for Engineering Education, Office of the Secretary, University of Illinois, Urbana, Ill., 476 pages, $4.

Summary of current research conducted in major U.S. engineering colleges.

Russian Engineers

The Training, Placement and Utilization of Engineers and Technicians in the Soviet Union, Engineers Joint Council, 29 West 39th St., New York 18, N. Y., 101 pages, $1.

Recent achievements and future goals of the Soviet Union. Includes footnotes, statistical data and photographs.

Information Retrieval

Chemical Engineering Thesaurus, American Institute of Chemical Engineers, 25 West 45th St., New York 36, N. Y., 256 pages, $5 to AIChE members, $10 to non-members.

A list of words for use with the concept coordination system of information storage and retrieval.

Natural Gas Analysis

Tentative Method for Natural Gas Analysis by Gas Chromatography, Natural Gas Processors Association (formerly Natural Gasoline Association of America), 421 Kennedy Building, Tulsa 3, Okla., 12 pages, 75 cents.

Chemistry Handbook

Handbook of Chemistry and Physics, 43rd edition, The Chemical Rubber Co., Publications Division, 2310 Superior Ave., Cleveland 14, Ohio. 3,467 pages, $12.

Water Cooling Towers

NFPA No. 214—Water Cooling Towers, National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 11 pages, 50 cents.

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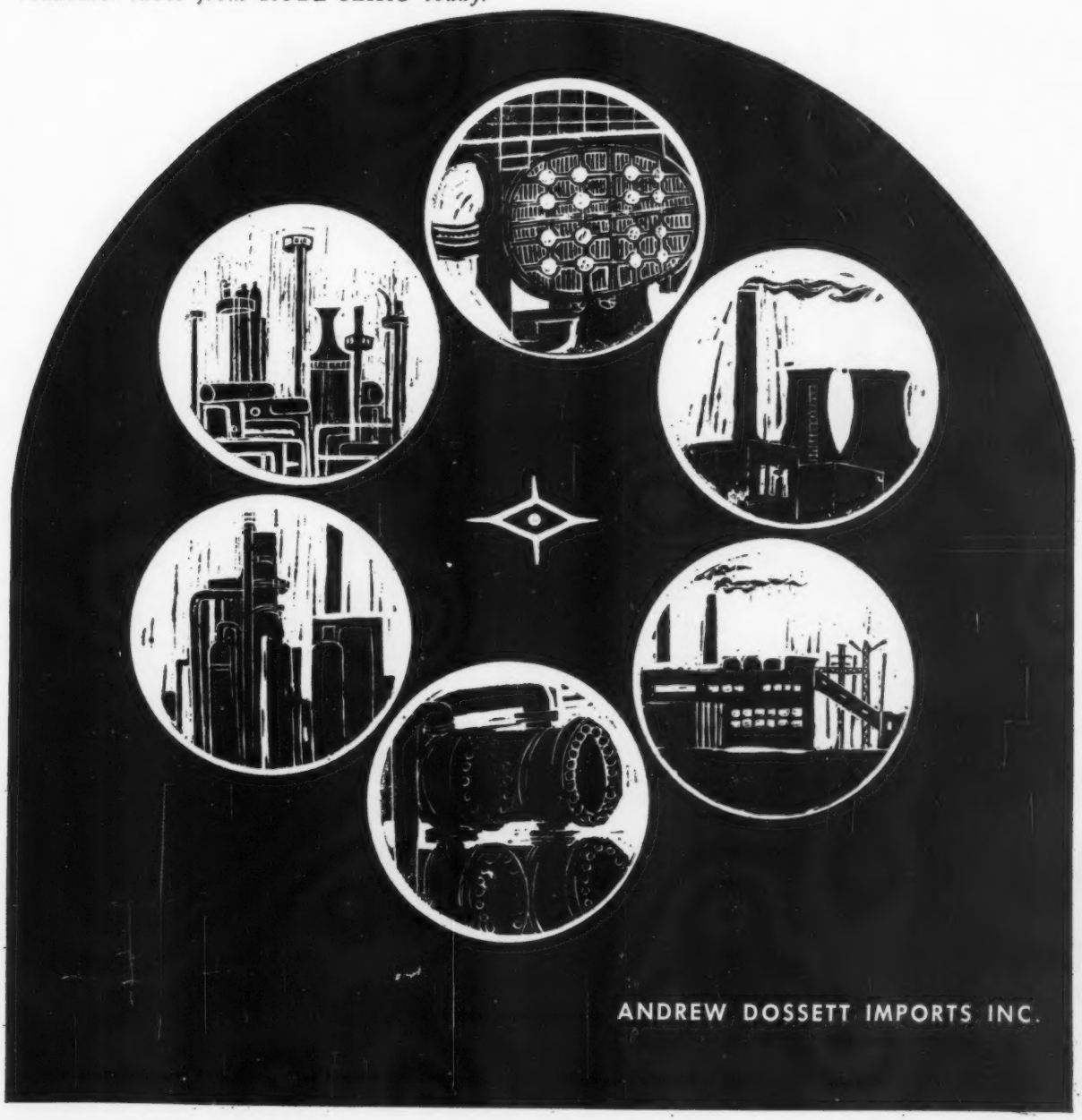
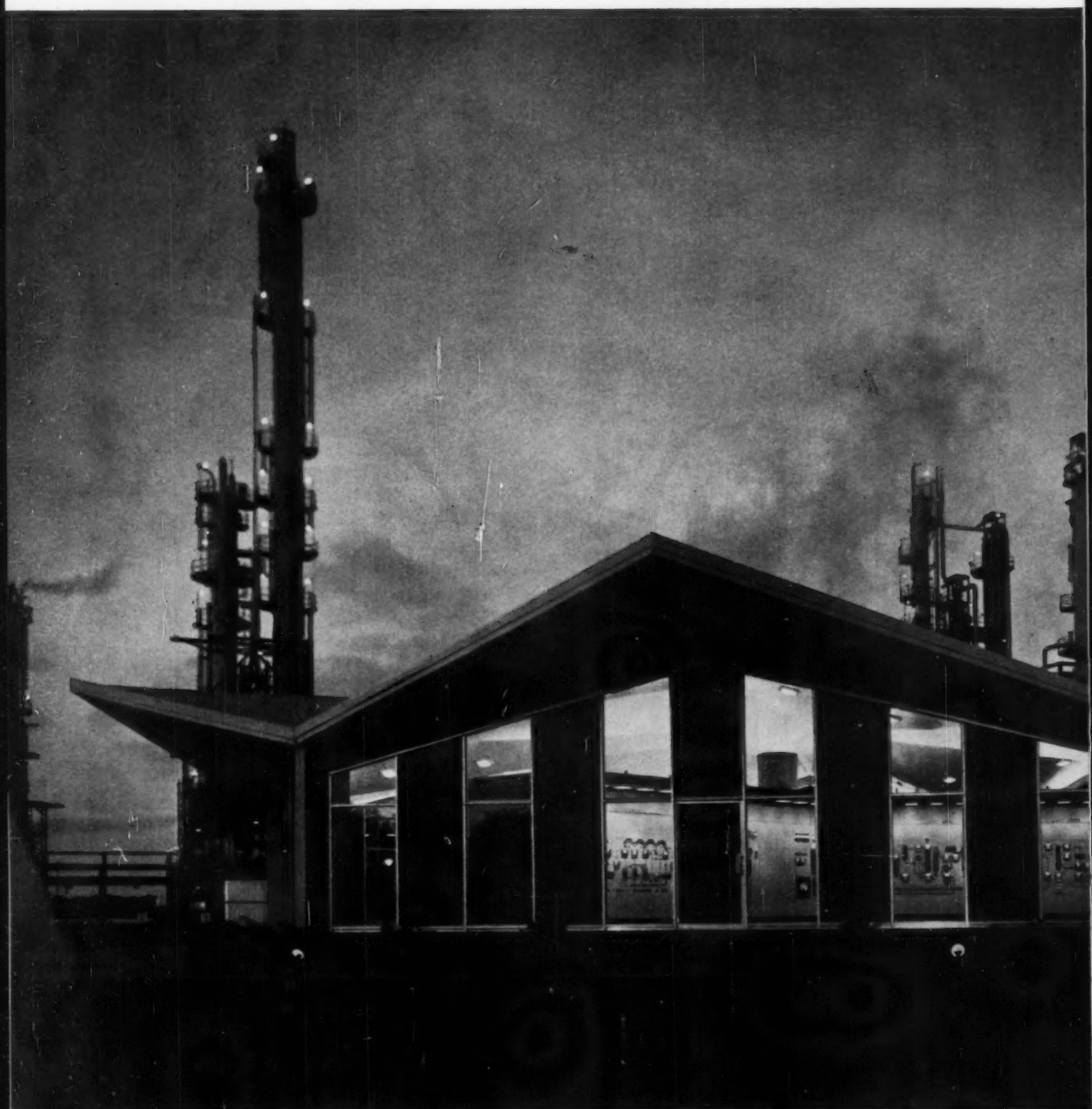
CAREFUL HYDROSTATIC AND EDDY-CURRENT TESTING of every tube, as well as thorough visual inspection also assure you of unexcelled reliability and long life. *And, the lower initial cost of Kobe tubes means immediate economy at time of fabrication, too.*

Why not investigate the many advantages of heat exchanger and condenser tubes from KOBE SEIKO today?



ANDREW DOSSETT IMPORTS INC.

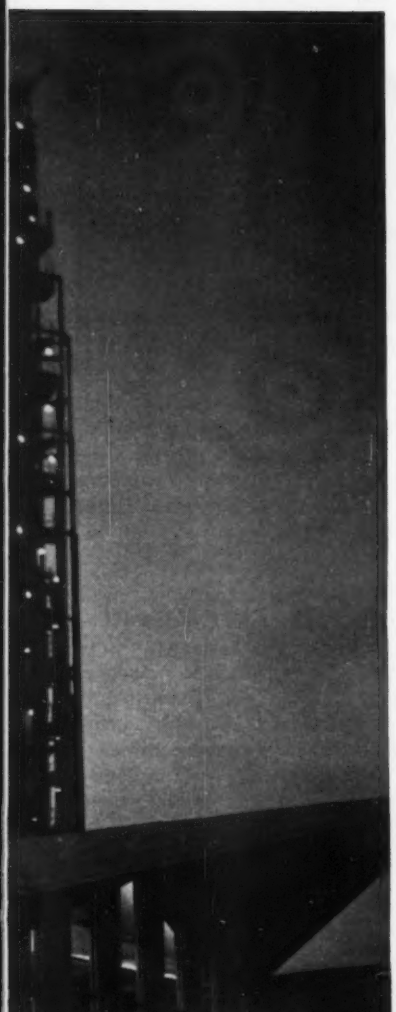
Foxboro pneumatic control huge Canadian



Photography by John K. Harris

THREE FOXBORO CONTROL PANELS for Imperial's Chemical Products Cracking Unit are housed in this unique hexagonally-shaped control room. Panels, which are arranged in a star-shaped pattern, contain 178 Consotrol recorders and controllers. Panels were built by The Foxboro Company, Limited, Montreal.

installed at Refinery and Petrochemical Plant



Imperial Oil's giant Sarnia Plant counts on Foxboro Consotrol* instruments for accurate, dependable control

From its star-shaped control room to its towering columns, they've used the most advanced refining techniques at Imperial Oil's 94,000 barrel-per-day refinery at Sarnia, Ontario.

Little wonder that accurate, dependable, low-maintenance Foxboro Consotrol instruments were installed. For example, clay treating, cracking and fractionation, ethylene recovery, butadiene extraction, refrigeration, light ends, Hydrofining, Powerforming, debutanizing, detergent alkylation, and production of Naptha Specialties — all operate under Foxboro control.

Actually, you'll find Foxboro small-case pneumatic consotrols serving leading refineries wherever reliable instrument performance is a must. If you're not familiar with the Consotrol story, ask your nearby Foxboro Field Engineer for full details. Or write for Bulletin 13-18. The Foxboro Company, 749 Neponset Avenue, Foxboro, Massachusetts.

Reg. U. S. Pat. Off.

FOXBORO
REG. U.S. PAT. OFF.

THESE FOXBORO CONSOTROL PANELS are installed in the Powerformer Unit Control Room.

Men in HPI...

Higgins

Bogart

J. T. Higgins has been assigned to work with **G. A. Davidson,** vice president, director and chief functional officer in charge of manufacturing, engineering and research. **N. T. Bogart** will succeed Higgins as vice president and general manager, Manufacturing Department, Standard's Western Operations, Inc. **P. N. Johnson,** previously vice president, California Oil Co., Western Division, succeeds Bogart as assistant general manager, Western Operations' Manufacturing Department.

Johnson

Harry F. MacPhee has been named general manager, engineering, Catalytic Construction Co. **Frank J. Knoll** has become manager, engineering production; and **Thomas G. Papavero** has been appointed manager, design engineering. MacPhee, formerly chief project engineer, joined Catalytic as a project engineer in 1951. Knoll, who also came to the company in 1951, was manager, design engineering. Papavero joined Catalytic in 1948 as a piping designer.

Ronald A. Graham has been named assistant to **Dr. J. William Zabor,** director of Research, Wyandotte Chemicals Corp. Graham joined Wyandotte in 1947. After being research project engineer and head of an engineering research section, he was appointed assistant to the director of contract research in 1953, manager of contract research in 1954, and director of contract research in 1957.

G. F. Dressel, Midland, Mich., has been elected president, Ethyl-Dow Chemical Co. He succeeds **Ivan F. Harlow,** who has resigned as president and from the board of directors. **Douglas E. Lake** of Dow's bromine section in Midland has been elected a vice president, member of the board, and general manager of Ethyl-Dow. **William R. Perdue, Jr.,** Ethyl-Dow treasurer and a director, also has been named a vice president. Perdue is a vice president and treasurer of Ethyl Corp.

Donald R. Leamy has been named supervisor, SunOlin Chemical Co.'s ethylene plant, Claymont, Del. **Ernest Artz** has been made chief, ethylene oxide plant, and **Bruce G. Hawthorn** has been placed in charge of the urea plant. Leamy has come to SunOlin from Olin Mathieson Chemical Corp., where he was assistant superintendent, Doe Run ethylene unit, Brandenburg, Ky. Artz joined SunOlin as a process engineering assistant in 1960. Hawthorn came to the firm in 1959 from Sun Oil Co.'s Marcus Hook, Pa., refinery.

Charles B. Miller and Dr. Curtis B. Hayworth have been named assistant

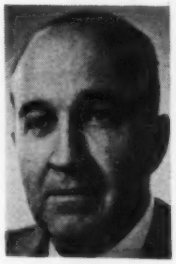
Miller

Hayworth

technical directors, Allied Chemical Co.'s General Chemical Division. Both will headquarter at the General Chemical research laboratory, Morris Township, N.J.

B. Ross Nason has been appointed director of manufacturing and engineering, Mobay Chemical Co., Pittsburgh, Pa., after serving as director of manufacturing for Monsanto Chemical Co.'s Inorganic Chemicals Division, St. Louis.

Lewis W. MacNaughton and J. Edgar Heston have been elected to the board of directors, Cities Service Co. MacNaughton is chairman of the



MacNaughton

Heston

board, DeGolyer and MacNaughton, geological consulting firm, Dallas, Texas. Heston is president and a director of Cities Service Petroleum in Bartlesville, Okla. He joined Cities Service in 1930.

E. H. Fallin, Jr., formerly technical and safety director for National Petroleum Association has been transferred to Tulsa, Okla., as manager, Management Services Department, National Petroleum Refiners Association. **Pat R. Wrigley,** who directed public and industrial relations for WPRA, will continue in the same capacity with NPRA in Washington, D. C.

Dr. Manus R. Foster has been promoted to senior research associate, Socony Mobil Oil Co.'s field research laboratory, Dallas, Texas. Since joining Socony Mobil in 1952, Dr. Foster has been in the fields of filter theory, decision theory and digital computation.

James W. Hyde has been named plant manager, Shell Chemical Co.'s Houston plant. Hyde replaces **Glenn Purcell,** who has retired after 32 years with the company. Hyde joined Shell Chemical in 1937.

Glenn D. Rucker has been assigned manufacturing responsibility for ethylene operations at Monsanto Chemical Co.'s Chocolate Bayou plant, near Alvin, Texas. Rucker, who has been in charge of ethylene operations at the company's Texas

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Men . . .

City plant, will also handle integration of Texas City ethylene operations with those of the Chocolate Bayou facility.

Joe E. Penick and A. E. (Tommy) Thompson, Mobil Oil Co., have exchanged jobs. Penick has moved from Mobil's Augusta, Kan., refinery to Torrance, Calif., as manager of that

Penick

Thompson

refinery, while Thompson has left Torrance to become manager at Augusta. Penick, who joined Mobil in 1942, had been manager at Augusta since 1959. Thompson was named manager, Torrance plant in 1949.

C. D. McLean has been promoted to supervising research engineer, petroleum Products Research Department, California Research Corp. He will headquarter at Louisville, Ky., as Calresearch representative.

F. L. Newby has been appointed manager of natural gas utilization, Standard Oil Co. of California. He succeeds the late **R. E. Clarke.** Newby joined Standard of California in 1935.

H. R. Barker has been elected vice president and general manager, Refinery Engineering, Ltd., Calgary, Alta. Barker was formerly project manager for The Refinery Engineering Co., Tulsa, Okla.

Dr. John J. Kolfenbach has been promoted by Esso Research and Engineering Co. to assistant director of the company's special projects unit concerned with new and improved solid rocket propellants.

John Y. Koo has joined the Engineering Department, Monsanto Chemical Co.'s Research & Engineering Division, St. Louis.

Leo Friend has been named director of chemical engineering development, The M. W. Kellogg Co., New York. Friend will manage the pilot plant, process development, and technical data groups. Friend, who joined M. W. Kellogg in 1934, had been an associate director of chemical engineering.

William F. Erbelding has joined the Whiting, Ind., research laboratories, American Oil Co. He will carry out research in developing new catalysts for refining processes.

R. W. Heath, vice president, Gas Department, and a director of Signal Oil & Gas Co., has been elected executive vice president. **Harold F. Clary** has been named senior vice president. He was a director, vice president, Legal Department, and general counsel.

R. D. Updegrove has been appointed a general supervisor in the Hydrocarbons Department at Monsanto Chemical Co.'s Chocolate Bayou plant, near Alvin, Texas, after serving on temporary special assignment for the company's Chocolate Bayou project at San Francisco.

P. H. Bohart, administrative vice president and coordinator, Gulf Oil Co., has been elected senior vice president. He will handle executive supervision of Gulf's Crude Oil Department, in addition to general corporate duties. **P. H. Clancy** has been named coordinator, Crude Oil Department. He was department manager.

G. H. Jefferis has been named superintendent of catalytic operations, Refining Department, California Oil Co.'s Eastern Division, Perth Amboy, N.J. **R. W. Keck** has replaced Jefferis as superintendent, manufacturing and utilities section, while **C. A. Petersen, Jr.,** has filled the post of senior operations planner, formerly held by Keck.

Dr. R. J. Miller has been appointed coordinator, research projects, Chemicals Research Division, Richmond Laboratory, California Research Corp. **Dr. R. T. Adams** has been made supervising research chemist, chemicals process development section. **G. B. Johnson** has been named

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The proof of the pudding, as they say, is in the eating. The Graham Heliflow Heat Exchanger—in thousands of installations—has given far more satisfying results than its users had anticipated—and by a generous margin! Not only from the standpoint of BTUs per dollars invested but because of the complete lack of maintenance, or any trouble whatever.

This extremely compact and rugged heat exchanger is a real "bearcat" for performance. Heliflow embodies the biggest single improvement in heat exchanger design within this century.

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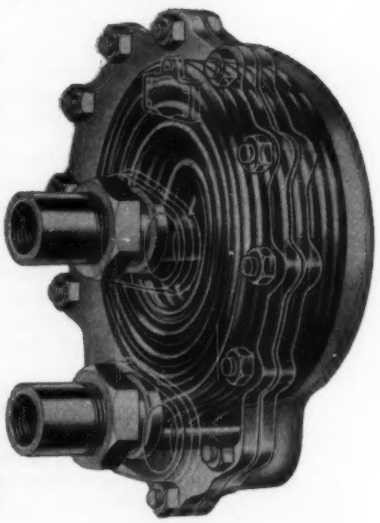
Yes, the proof is in the eating, as those thousands of users have found. If you want your problem licked call our nearest sales engineer; he is trained to serve up the answers to your needs.



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Men . . .

supervising research chemist, chemicals product development section.

S. W. Dedman has been promoted to assistant general foreman, Solvents Department, and **J. S. Keating** has been named assistant general fore-

Dedman

Keating

man, Butyl and Butadiene Department, Process Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery.

J. L. Darragh has been appointed section supervisor, chemicals product development section, Richmond Laboratory, California Research Corp. **Dr. J. D. Knight** has been named section supervisor, chemicals product technical service section. **J. E. Hanson** has become technical assistant to the manager, Chemicals Research Division, replacing Knight.

Victor E. Schermerhorn has been promoted to manager, crude oil supply section, The Standard Oil Company (Ohio). He will move to Cleveland from Oklahoma City. Schermerhorn joined Sohio in 1947 as staff assistant at the St. Louis offce.

Joseph C. Swidler, recently appointed member of the Federal Power Commission, has been named FPC chairman. Swidler replaces **Jerome Kuykendall,** who will continue as an FPC member. **Howard Morgan** has been elected FPC vice president for the rest of 1961.

Ben Ramsey, lieutenant governor of Texas has been appointed to the Texas Railroad Commission replacing Olin Culberson, who died June 22. Ramsey is in his sixth term as lieutenant governor.

Paul M. Pitts has become manager, Research Division, The Atlantic Re-

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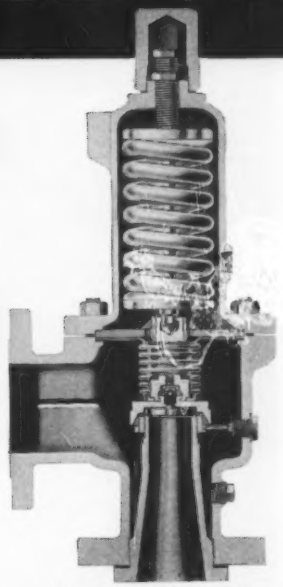

Series 2600 . . Balan-Seal bellows. 150 to 6000 psig. Also without bellows.

Farris Process Safety-Relief valves have unique design features which provide product serviceability and dependability unmatched by *any* competitive valve. True value is "built into" Farris valves.

- **2½ to 1 ratio—guide length to guide diameter—prevents galling and hanging up.**
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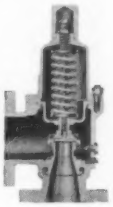
- **Elimination of effects of back pressure by "BALAN-SEAL" bellows permits use of smaller discharge piping . . . Saves up to 15 times the cost of the valves . . . isolates internal working parts from lading fluid.**
- **Industry's most complete line. Available in cast iron, steel and special materials. Sizes ½" to 8". Pressures to 10,000 psig. Temperatures to 900°F. Enclosed or exposed springs. Plain, open lever or packed lever construction.**

All Farris Nozzle Valves Conform To ASME Power Boiler Code, Section 1, and The ASME Unfired Pressure Vessel Code, Section 8.

Series 2740 & 2741 . . . simple, rugged cast steel design. Pressures to 5000 psig @ 750°F.

Series 2745 . . . Durable, compact, high pressure nozzle valve. Internal parts 316 stainless steel. Pressures to 10,000 psig.

Series 2950 . . . Cast iron valve similar to Series 2600. Max. pressure 250 psig. @ 450°F, 400 psig. @ 150°F.



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At Richfield Refinery, B&W boiler "team" provides

dependable operation with maximum

Two highly efficient B&W boilers of entirely different designs — system engineered into a money saving "team" — are providing operating flexibility and dependability at Richfield's Wilmington, California refinery.

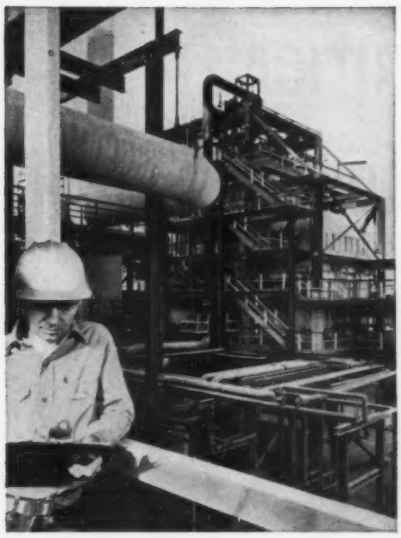
The two boilers are the CO* Boiler, which operates on waste gases from the refinery process, and the PFI, which burns refinery gas, natural gas, or oil with equal ease.

The CO Boiler has been base loaded at 340,000 lbs./hr. full load since its installation in 1954, with an availability exceeding 96%. Developed and pioneered by B&W, the CO Boiler improves refinery economy by burning cat-cracker gas that would otherwise be wasted. The Richfield unit is typical of the many CO Boilers that have solved air pollution problems.

Supplementing the steam produced by the CO Boiler, the PFI boiler is equipped to use the lowest cost auxiliary fuel, whether oil or gas, at all times.

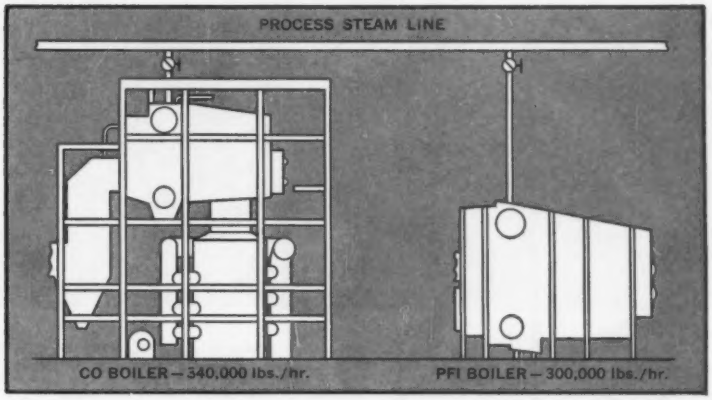
Reg. U.S. Pat. Off.

MAXIMUM AVAILABILITY — No unscheduled outages have occurred since the CO Boiler (left) and the PFI boiler (right) went on the line. This complete freedom from unscheduled shutdowns plus sustained high efficiency provides Richfield with dependable steam at 640,000 lbs./hr.



PAYS FOR ITSELF—Burning cat-cracker gas that would otherwise go up the stack and pollute the atmosphere, the B&W CO Boiler cuts operating costs to the extent that it, and others like it, pay for themselves in fuel savings in less than 3 years.

FLEXIBILITY OF OPERATION — The PFI boiler helps keep steam generation costs down by providing immediately all needed steam in excess of that which can be obtained by burning the waste gas.



EASY TO OPERATE, INTEGRATED CONTROL CENTER—Fully automated control center equipped with Bailey meters ties this boiler "team" together as a dependable source of low cost steam to meet refinery requirements.

fuel savings

This compact, versatile boiler, designed for 300,000 lbs./hr. supplies steam required in excess of that produced from the waste gases, and responds immediately to changing conditions.

By continually developing more efficient and economical ways to generate steam, B&W has helped many industries to meet growing steam demands at lowest possible cost. For further details, contact The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

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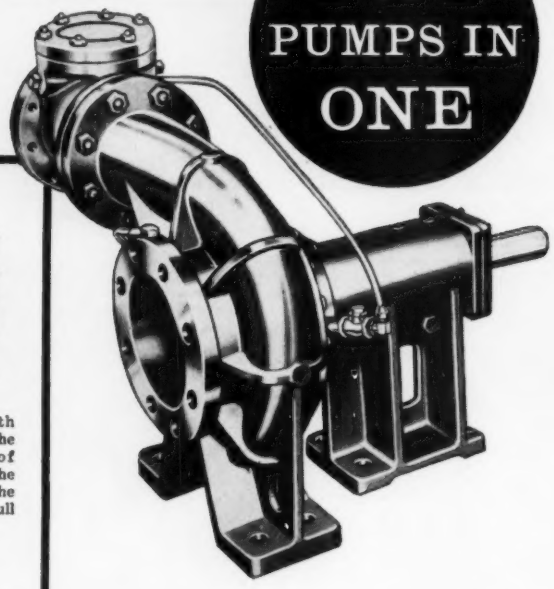
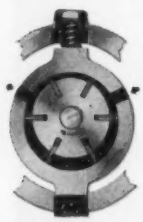
OVERCOME CRITICAL NPSH CONDITIONS WITH *ROTO-PRIMES*

TWO PUMPS IN ONE



Full Priming—With air or vapor in the lines, pressure of spring on top of the movable slide holds the priming pump in full priming position.



Partial Priming—As the pump evacuates air and vapor from the lines, liquid pressure builds up on the underside of the slide, moving it upward toward neutral.

Neutral—When all air and vapor are removed, liquid pressure equalizes spring pressure and the pump automatically slides into neutral...where it remains until air and vapor again appear in the system.

Having trouble with loss of available NPSH when pumping liquid hydrocarbons? Here's your answer — Gilbarco Roto-Prime centrifugal pumps. Roto-Primes are a unique integral combination of a high efficiency centrifugal pump and a variable-capacity positive vane type. Vane pump automatically goes into operation whenever air or vapor enters the centrifugal inlet, providing fast, positive automatic self-priming. These pumps, therefore, *will continue to operate when available NPSH drops below normal requirements.* The 4" x 3" models, as an example, will pump air or vapor from 50 feet of four-inch pipe in less than 60 seconds. Capacities up to 1,600 G.P.M.

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Gilbarco

Gilbert & Barker Manufacturing Co.
West Springfield, Mass.
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Men . . .

fining Co., Philadelphia. **James E. Conner, Jr.**, will work under Pitts as head of physical and organic chemical research. **William K. Griesinger** has been appointed Development Division manager.

Dr. Fred H. Kant and Emil H. Lewis have been appointed research associates, Esso Research and Engineering Co. Both men are in the firm's Process Research Division.

James L. Patton has been appointed manager, Refinery Process Division, The M. W. Kellogg Co., New York. Patton will handle economic and technical evaluation and development of process designs for complete refineries and refinery units. He joined Kellogg in 1944. He had been a Refinery Division process manager and manager of the Chemical Process Division.

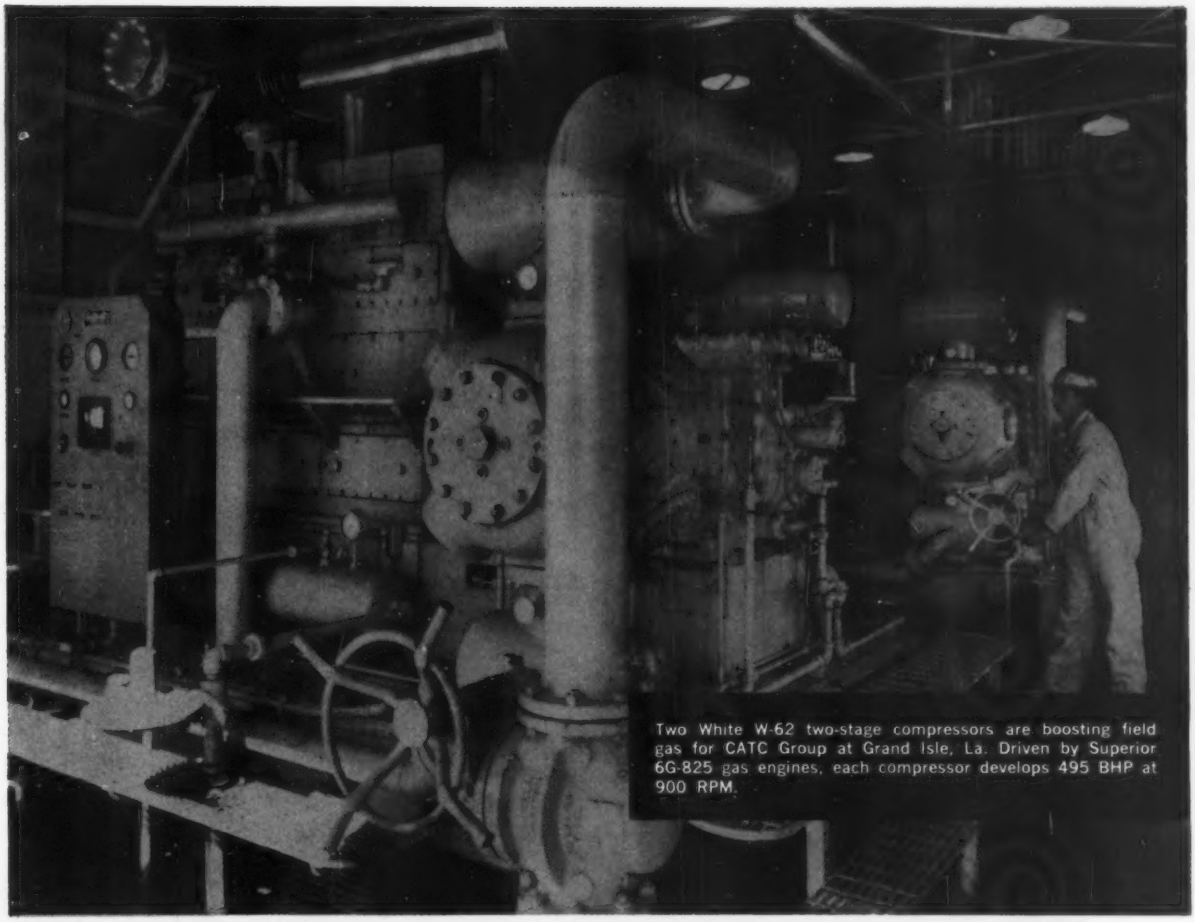
Patton

Amel R. Meyer has been named section head, Research and Development, Whiting, Ind., refinery, American Oil Co. He will head research and development on metals and their use in refinery construction and maintenance.

Russell G. Ernest and **Charles B. Moore** of Baton Rouge, La., have been assigned to the headquarters Manufacturing Department, Humble Oil & Refining Co. Ernest has become assistant manager of specialty products planning, and Moore has been named assistant manager of fuel products and general planning.

A. James Fiske has been appointed safety director, Monsanto Chemical Co.'s Chocolate Bayou plant near Alvin, Texas, after serving as a safety engineer for the Plastics Division's plant, Springfield, Mass.

Ralph House has been appointed research associate, Chemicals Division, Richmond Laboratory, California Research Corp. House joined Calre-



Two White W-62 two-stage compressors are boosting field gas for CATC Group at Grand Isle, La. Driven by Superior 6G-825 gas engines, each compressor develops 495 BHP at 900 RPM.

ONSHORE-OFFSHORE... CATC* Served

By White/Superior Engine-Compressor Sets

Two White/Superior engine-compressors on field gas booster service for CATC Group (Continental Oil Co., Operator) will be followed by two additional units, offshore. The recent order specifies two W-64 three-stage compressors driven by Superior 8G-825 gas engines, each developing 660 BHP at 900 RPM. Job site is CATC's Block 30 offshore platform, West Delta field, off Grand Isle, La. White's is the only *matched-design*, balanced-opposed unit available in the 660 HP category. It's specially suited to offshore service because there are no horizontal primary unbalanced forces to shake the platform and disturb auxiliary equipment and instrumentation.

White's medium speed, heavy duty compressors—two, four and six-cylinder models, 200 to 1000 BHP—offer cylinder sizes from 4000 PSI, 2⅝" dia. to 85 PSI, 22½" dia., providing 68 standard cylinders. Custom sizes and designs are also available. Write for new Bulletin 124, describing compact packages for gas lifting, boosting, repressuring, peak shaving, underground storage applications, etc. White Diesel Engine Division, Springfield, Ohio.

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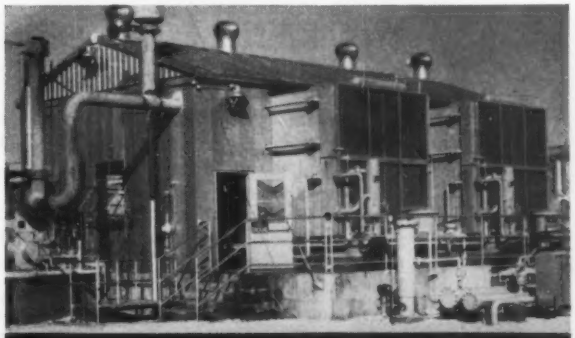
ENGINES / COMPRESSORS



Engine exhaust gas is used for regeneration purposes on glycol dehydration unit.

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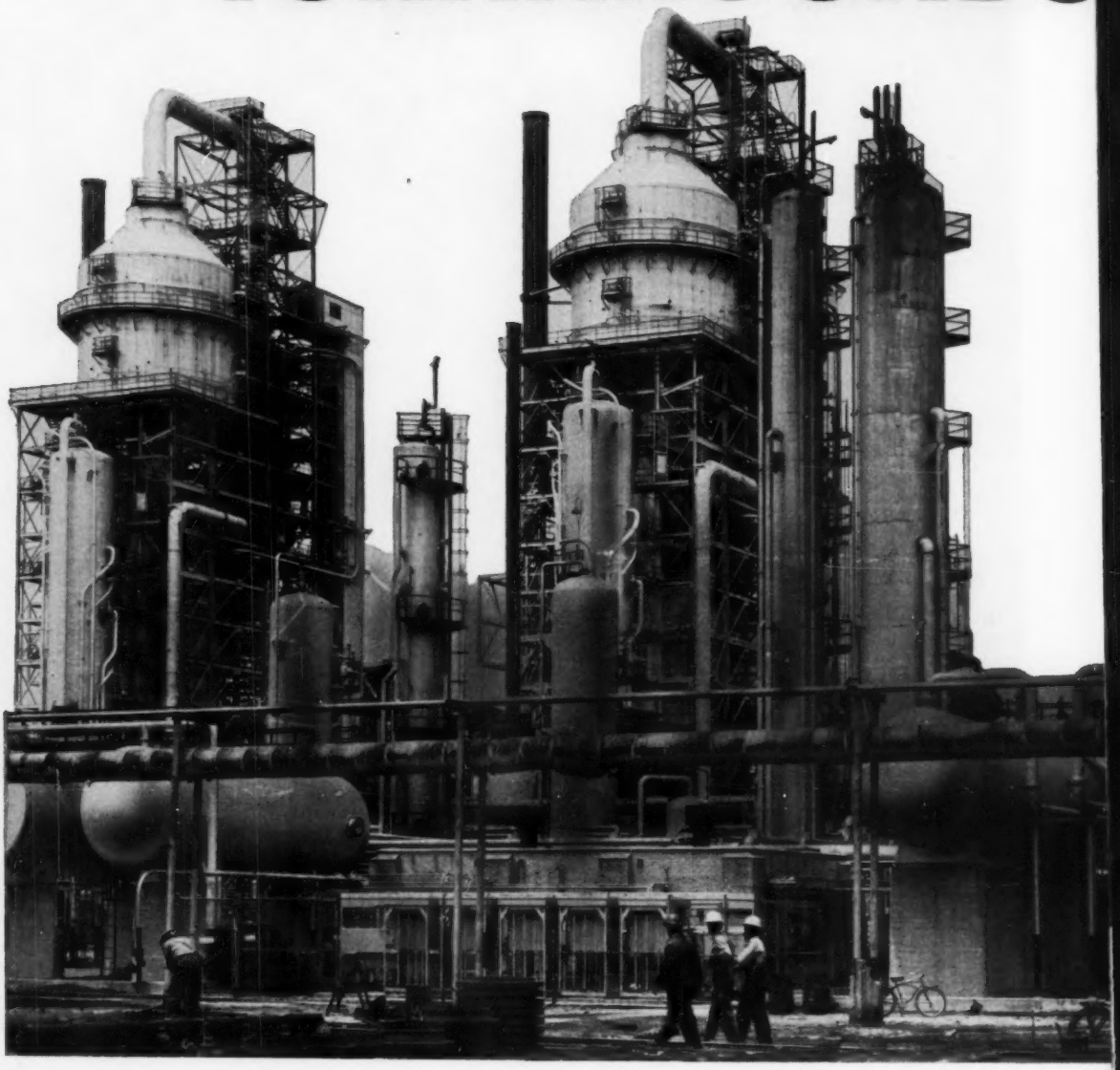
Make shorter work of TURNAROUNDS



Every OAKITE ECP utilizes chemical cleaning for towers

Where carbon and iron oxides and sulphides must be removed: circulate Oakite 85. Combining acid and solvent cleaning properties Oakite 85 penetrates heavy scales and corrosion-type soils, tears them from equipment walls, then rinses freely and completely. It's safer than raw acids, because it's inhibited against attack on ferrous metals . . . easy on synthetic rubber. One user says:

When this 40-ft., 12-tray tower was off-stream previously, "hand" cleaning required 5 days and $3,000. Using Oakite 85 by circulation method, we did a complete job of removing fouling soils in just 32 hours . . . for only $750.

For heavy oil, grease-laden soils and light rusts: circulate Oakite 77. Heavy-duty alkaline cleaning properties make Oakite 77 superior for penetrating, dissolving and dispersing heavy-oil and carbonaceous soils. It picks up light rust, too . . . leaves towers and tubes in top operating condition.

In cases where extra boosting power is called for to remove abnormally stubborn soils—add Oakite Acalaid to your cleaning solution. This brand new additive permits deeper penetration of soils . . . intensifies the purging action of your acid or alkaline cleaning agent . . . gives you a speedy, economical answer to your toughest tower-cleaning problem.

with an Oakite ECP

engineered cleaning program

A 90-foot tower cleaned in 15 hours . . . crude tower and heat exchanger purged to 99% cleanliness in 21 hours . . . partly plugged bundles saved from the scrap pile in just a few hours . . . 3½ *days* cut from previous record for cleaning an absorber . . . 5 days slashed from catalytic reformer turnaround time. These are *some* of the results of Oakite technical service.

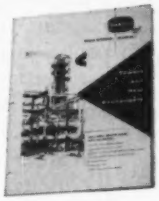
In each case, the procedure was initiated through the tower and tube bundle recommendations of an Oakite ECP. Did they save time, save cost, save trouble? You bet!

WHAT IS OAKITE ECP?

It's an Engineered Cleaning Program that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by materials known to make short work of refinery soils, by proved *methods.*

Ask the Oakite Engineer to recommend the best procedure for your next turnaround and follow up with an ECP for your refinery. Or, send for Bulletin F-10102 on tower and heat exchanger cleaning. Write Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.



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over 50 years' leadership in industrial cleaning

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This LITTLE trap does a BIG trapping job— and reduces the cost of discharging condensate

NEW NICHOLSON N-150 THERMOSTATIC STEAM TRAP

- ... All steel construction for rugged durability.
- ... Design simplified for quick, low cost maintenance.
- ... Compact, lightweight, easily installed. Can be inspected without breaking pipe connections.
- ... Equipped with Nicholson steam-saving Baffle*.

For lowest cost-per-pound of condensate handled, this trap is by far your best buy. Like all Nicholson Thermostatic Traps, it opens ONLY when necessary . . . that is, when sufficient condensate collects in trap body to surround the Monel bellows . . . ONLY then does the pressure inside the bellows reduce below line pressure, the resulting differential causing bellows to contract and instantly activate complete discharge. Body is cast steel and cover forged steel. Cover screws, valve and valve seat are hardened stainless steel. Just *one* working part, so maintenance is practically nil. In ½" and ¾" sizes. For pressures from vacuum to 150 psig. Write for details, including the name of the Nicholson man in your area.

*Patent applied for

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Our 80th Year

Men . . .

search in 1947 as a research chemist. Since June 1957, he has been group supervisor, chemicals product development and technical service section.

Harry M. Sisson has been named director of administration, Organics Division, Olin Mathieson Chemical Corp. **J. J. Hanrahan** has been appointed division personnel and labor

Sisson

Hanrahan

relations manager. Sisson, formerly corporate organization planning manager, joined Olin in 1954 from Merck & Co., where he was manager of organization planning. Hanrahan, who came to Olin in 1957, was assistant to the director of administration for the division.

J. A. Hapke, former Service Division manager at Standard Oil Co. of California's El Segundo, Calif., refinery has been appointed managing director of the operating company for a proposed fertilizer plant at Visakhapatnam, India. Standard of California's subsidiary, California Chemical Co., is participating as a minority stockholder in the venture.

Walter I. Kimoto has joined the Whiting, Ind., research laboratories, American Oil Co., to carry out exploratory research in organic chemistry.

C. A. Deveny has been promoted to staff engineer, Cracking and Light Ends Department, Process Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery. He is responsible for design and maintenance engineering of the three catalytic cracking units.

S. McBrayer Burnam has been elected secretary-counsel, Ashland Oil & Refining Co., Ashland, Ky. Burnam succeeds the late **E. L. Mc-**

another
TRETOLITE SERVICE
report

Many refiners are cutting costs . . . improving marketability with Tretolite Company products

TRET-O-LITE* *Demulsifiers*

TRET-O-LITE demulsifying chemicals were developed and pioneered to enable producers to reclaim profitably otherwise unmarketable emulsified crudes. Refiners also use TRET-O-LITE emulsion-breakers to salvage usable oil trapped in "tank-bottoms", thereby gaining valuable storage capacity lost when tank-bottoms accumulate. TRET-O-LITE demulsifying chemicals are effectively used to reclaim usable oils from refinery waste disposal systems and separator traps.

If oil and water emulsification is causing an operating problem in your refinery, call Tretolite.

TRET-O-LITE* *Desalting Chemicals*

The Tretolite Company pioneered the use of chemicals in crude oil desalting, and developed the first desalting system in which chemicals provided emulsion destabilizing action.

Refiners all over the world now rely on TRET-O-LITE for efficient, economical desalting performance.

TRET-O-LITE Desalting Chemicals also are widely used in chemical-electric desalting, as well as chemical aid to electric desalting when certain adverse treating conditions are encountered.

Ask your Tretolite Refinery Service Engineer about the economy of TRET-O-LITE *Desalting Chemicals.*

KONTOL* *Corrosion Inhibitors*

KONTOL Corrosion Inhibitors are liquid organic semi-polar compounds available in a variety of formulas. They adsorb at metal surfaces to form an impervious corrosion-inhibiting film. KONTOL Corrosion Inhibitors prevent corrosion in refinery equipment by protecting against attack by chlorides, sulfides, organic acids and hydrogen blistering. They are effective detergents and provide an economical means for maintaining cleanliness and heat transfer efficiency in condensers and exchangers.

KONTOL *Corrosion Inhibitors have been cutting maintenance costs for refiners for many years. Complete information is yours on request.*

TOLAD* *Fuel Additives*

TOLAD Fuel Additives are ashless, totally oil-soluble compounds. They stabilize color in heating oils and diesel fuels. They effectively disperse the insoluble solids which form sludge and impair burning qualities.

TOLAD additives have excellent water tolerance characteristics which prevent loss to water bottoms in fuel storage. They are available as inhibitor or inhibitor-dispersant formulations. TOLAD is approved, and used, by leading railroads.

Get all the facts on this new Tretolite product. In test after test, TOLAD *has provided better fuel stability at lower cost. Why not prove this to your own satisfaction—and profit.*

For complete information on these, or any Tretolite Company product or service, ask the Man in the Red Car, or write

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FACTS FOR REFINERS

psd

INSTRUMENTATION FOR AUTOMATION

PROCESS INSTRUMENTATION ADDS TO REFINING PROFITS

Precision Scientific Development under license from Standard Oil Co. (Ind.)

The PSD AUTOMATIC REID VAPOR PRESSURE APPARATUS allows refiners to maintain closer approach to specifications and seasonal targets, gaining better utilization of valuable butane in motor fuels. When average Rvp of gasoline is increased 0.1 lb., the resulting butane conservation may amount to $4 per 1000 Bbl. of gasoline. For a 30,000 B/D refinery, profits can be increased $20,000 annually. In addition, continuous Rvp monitoring speeds batch blending of gasolines and adds flexibility to continuous blending systems at refineries or at pipeline terminals. More-efficient utilization of existing facilities means lower processing costs and deferment of capital expense. For new facilities, better efficiency allows economy in design and lower initial cost. The AUTOMATIC REID is explosion-proof, provides a continuous record, and is adaptable to closed-loop control applications.

The AUTOMATIC END POINT RECORDER helps increase yields of distillate fuels, helps protect reforming operations, and helps improve the quality of gasoline blending stocks. End point control of No. 1 fuel oil may add $100 daily to the profit of a 30,000 B/D refinery. When reformer feed contains excessive heavy ends, reforming capacity suffers and potential feed stocks are often diverted to distillates manufacture. Protecting reformer capacity may avoid hidden loss of profits amounting to more than $100 daily. Cat naphtha endpoint is often a limitation on quality. Protection of this important property allows better balance of heavy naphtha usage between gasoline and distillate fuels. The AUTOMATIC END POINT RECORDER is explosion-proof and simulates the ASTM test, recording the highest vapor temperature actively, manual introduction of samples allows surveillance of several streams as needed.

The CONTINOUS FLASH POINT RECORDER assists to maximize distillate fuel yields and safeguard product quality. No. 1 fuel production can be increased as much as 5% when flash point is brought 5°F. closer to specification. This more-profitable use of heavy naphtha may be worth $27,000 annually to a 30,000 B/D refinery. Continuous, positive monitoring of blending and transfer operations reduces reprocessing of off-test product, helps reduce storage requirements and speeds process decisions. These cost-saving advantages far outweigh the price of the instrument. The CONTINUOUS FLASH POINT RECORDER is explosion-proof, accurate to 2°F. over the range 80-190°F. For tropical installations, mechanical refrigeration can be supplied. An optional strip-chart recorder provides a continuous signal for use with automatic control systems.

The AUTOMATIC LOADING RACK FLASH TESTER gives positive assurance that deliveries of home heating fuels are safe, free from low-flash contamination. Transports are released without delay for laboratory tests; return-haul and demurrage charges are eliminated. Loading documents are automatically stamped when load meets flash requirements. Warning light appears and automatic stamp is deactivated if load is contaminated. The instrument may be preset for any temperature between 100 and 140°F., to conform to local regulations. Explosion-proof construction permits installation in loading areas, convenient for loaders and drivers. Automatic stamp permits use at keylock or remotely-operated terminals.

We're sure you know the possibilities in your processes. Let us send you more information on our instruments. We'll be glad to help solve your problems just ask us.

Precision Scientific Development manufacturers under exclusive licenses, quality-sensitve process instruments that offer many opportunities to reduce refining costs and increase profits. Some of the typical ways each instrument can help your processes are described. You'll see that almost any refinery can make more money through process instrumentation.

psd **Precision Scientific Development**

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Men . . .

Donald. Burnam joined Ashland Oil in 1939 as a legal assistant, and in the following year was named assistant secretary-counsel.

Dr. Carl E. Barnes has joined FMC Corp. (formerly Food Machinery and Chemical Corp.) as vice president, research. Dr. Barnes, who will headquarter in New York City, will direct research, development and patent activities of FMC's chemical divisions. He has been a research executive of Minnesota Mining and Manufacturing Co. for the past eight years. Dr. Barnes received his M.A. and Ph.D. degrees from Harvard University.

Barnes

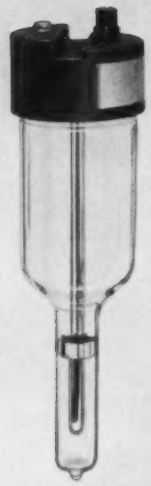
J. D. De Grandis has become manager of product supply, British American Oil Co., Ltd., with headquarters in Toronto, Canada. De Grandis joined B-A in 1943 and from 1952 to 1959 held senior administrative posts at its Clarkson, Ont., refinery.

Dr. William E. Lovett has been appointed head of the motor gasoline additives section, Esso Research and Engineering Co., Linden, N.J. Dr. Lovett, who had been a project leader, has been with Esso Research over five years.

William B. Ross has joined the Whiting, Ind., research laboratories, American Oil Co., as a technical-computing specialist. He will work with electronic computers as they are applied to problems in the petroleum industry.

John C. Hayes has been named associate coordinator, Platforming research at Universal Oil Products Co. Hayes, formerly a research chemist, joined UOP in 1957.

Robert P. Barnett has been elected vice president, Atlas Chemical Industries, Inc. He will continue to be general manager of the International Division, a post he has held since 1959. Barnett joined Atlas as senior



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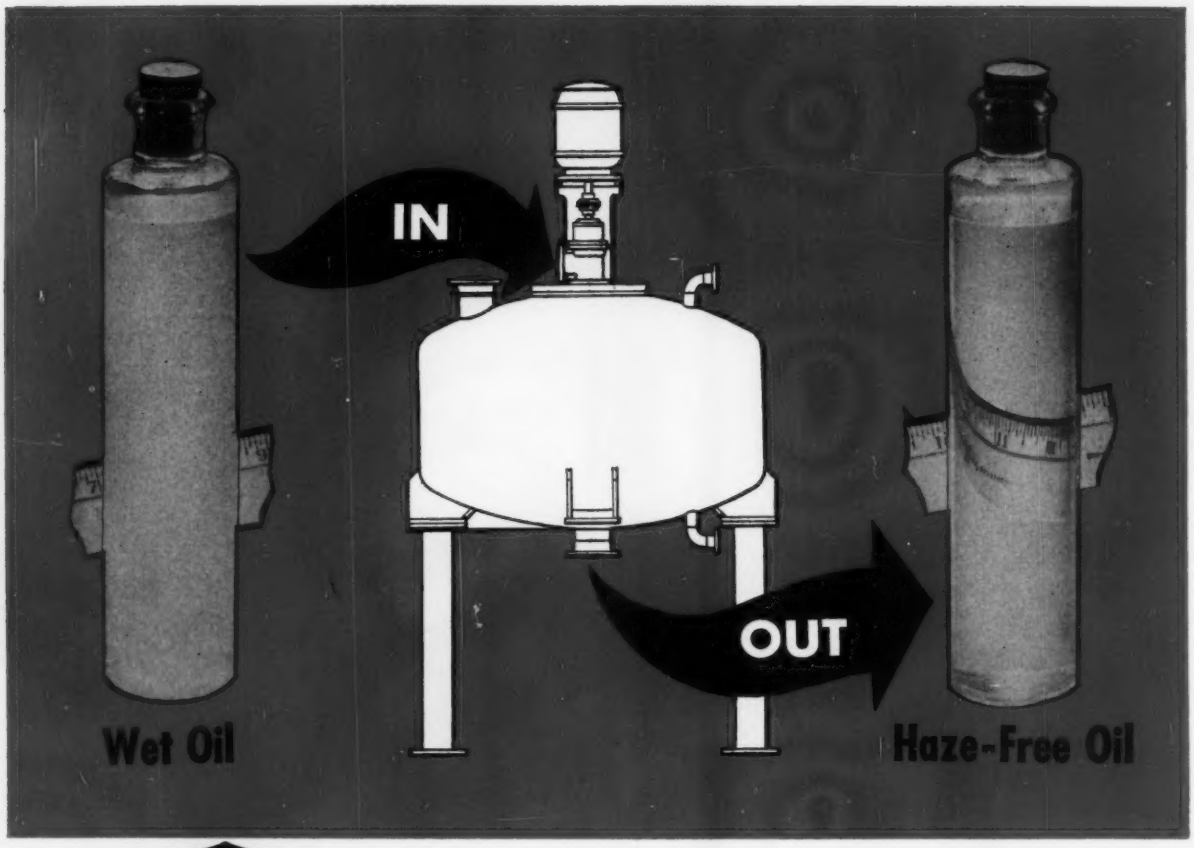

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F. J. McConnell Co., New York

E161

Men . . .

legal assistant in 1951, and became assistant to the senior vice president in 1958.

T. S. Farmer and Dr. R. H. Perry have been promoted to section heads, Humble Oil & Refining Co.'s Research and Development Division,

Farmer

Perry

Baytown, Texas. Farmer heads the engineering and operations section and Dr. Perry the section that is engaged in exploratory research on petrochemicals.

George A. Trigaux has been named manager, new product development, Union Carbide Olefins Co. He was previously with Union Carbide Chemicals Co. as new chemicals product manager, epoxies and plasticizer group. Trigaux joined Union Carbide in 1946.

Dr. P. S. Magee has been promoted to senior research chemist, chemicals process development section, Richmond Laboratory, California Research Corp. His work at Calresearch has been in aromatic di-isocyanates, halogenation of aromatic compounds, polyesters, alpha-olefin derivatives, and selective hydrogenation of di-olefins.

H. Laurance Fuller has joined the Whiting, Ind., research laboratories, American Oil Co. He will study the commercial feasibility of new petroleum refining processes that originate from laboratory research.

T. J. McCann has joined Catalytic Construction of Canada, Ltd., as process engineer. He will assist in the engineering of petroleum refineries and petrochemical plants being engineered and constructed in Canada by Catalytic.

Dr. Carlisle M. Thacker has resigned as technical director of Taylor Fibre Co., Norristown, Pa., to devote full time to developing processes for making carbon disulfide from fuel oils and consultation on technical and economic matters pertaining to chemicals and petrochemicals.

Kerry Mills has been promoted to chief chemist, American Oil Co.'s Texas City refinery. Mills succeeds **John Grant,** who is being transferred to American Oil's Research and Development Department, Whiting, Ind.

Robert S. Kleppe has been named section head, General Engineering Division, Esso Research and Engineering Co. Kleppe joined Esso in 1952.

Cleveland Lane has been named assistant to the president, Goodrich-Gulf Chemicals, Inc. Lane was assistant to the president, Manufacturing Chemists' Association, Inc.

Gregory B. Stone has been appointed superintendent of personnel, Oleum refinery, Union Oil Co. of California. Stone joined Union Oil at Oleum in 1926.

Paul B. Cornell has been named assistant manager of Allied Chemical Corp.'s Solvay Process Division plant, Moundsville, W. Va. Cornell joined Solvay's Detroit plant in 1950.

R. B. Nesbitt has been promoted to supervising engineer, Cracking and Light Ends Department Process Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery. He is in charge of the catalytic light ends section, the group that provides technical assistance in keeping four of the refinery's large units that process light hydrocarbons in top operating condition.

Nesbitt

William F. Ellison has joined Monsanto Chemical Co.'s Research & Engineering Division at its Research Center, St. Louis.

Edward J. Bourne has been appointed a technical computing supervisor, Whiting, Ind., research labora-

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Fullerton, California

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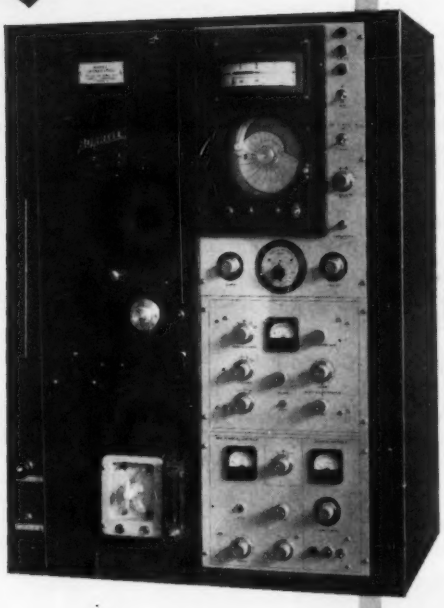

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Men . . .

tories, American Oil Co. Bourne, who joined the company in 1950, has specialized in applying electronic computers.

Dr. Leon B. Shore has been named an assistant director, Products Research Division, Esso Research and Engineering Co. Dr. Shore has been with Esso Research since 1953.

Dr. W. J. Farrissey has been promoted to senior research chemist, Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas. He is engaged in studies of hydrocarbon oxidation processes to understand fundamental chemical reactions and derive new intermediates for plastics and fibers.

Dr. Ronald T. Macdonald has been named research associate, California Research Corp. Dr. Macdonald joined Calresearch in 1935.

Howard W. Olsen has been promoted to senior staff engineer, American Oil Co.'s General Engineering Department, Whiting, Ind. Olsen started at American Oil's Sugar Creek, Mo., refinery in 1951.

Hugh C. Marx has been appointed organization planning manager, Olin Mathieson Chemical Corp. Marx joined Olin's Planning Department, Metals Division, in 1959.

Bernard Ostrofsky has been made senior project supervisor, Research and Development Department, Whiting, Ind., refinery, American Oil Co. He joined the company in 1954.

— *Deaths* —

Albert S. Orr, 58, director of product quality coordination, Refining Department, Gulf Oil Corp., died August 13 at Long Beach, N. J. Orr, who lived at Mount Lebanon, Pa., was with Gulf Oil since 1924.

Robert M. Aude, 47, president of Heyden Chemical Division, Heyden Newport Chemical Corp., died August 20 at his home in Upper Saddle River, N. J. He was with Heyden eight years.

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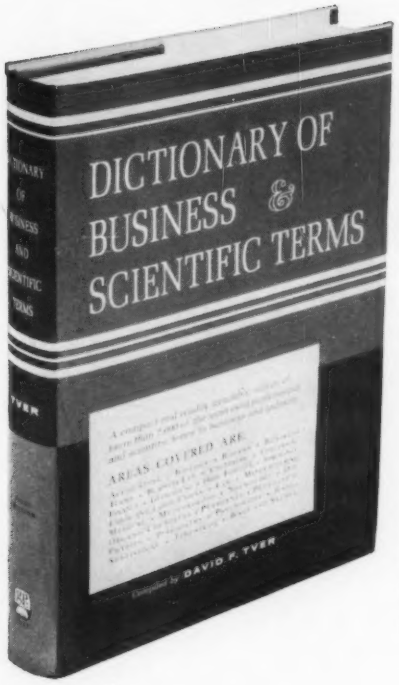

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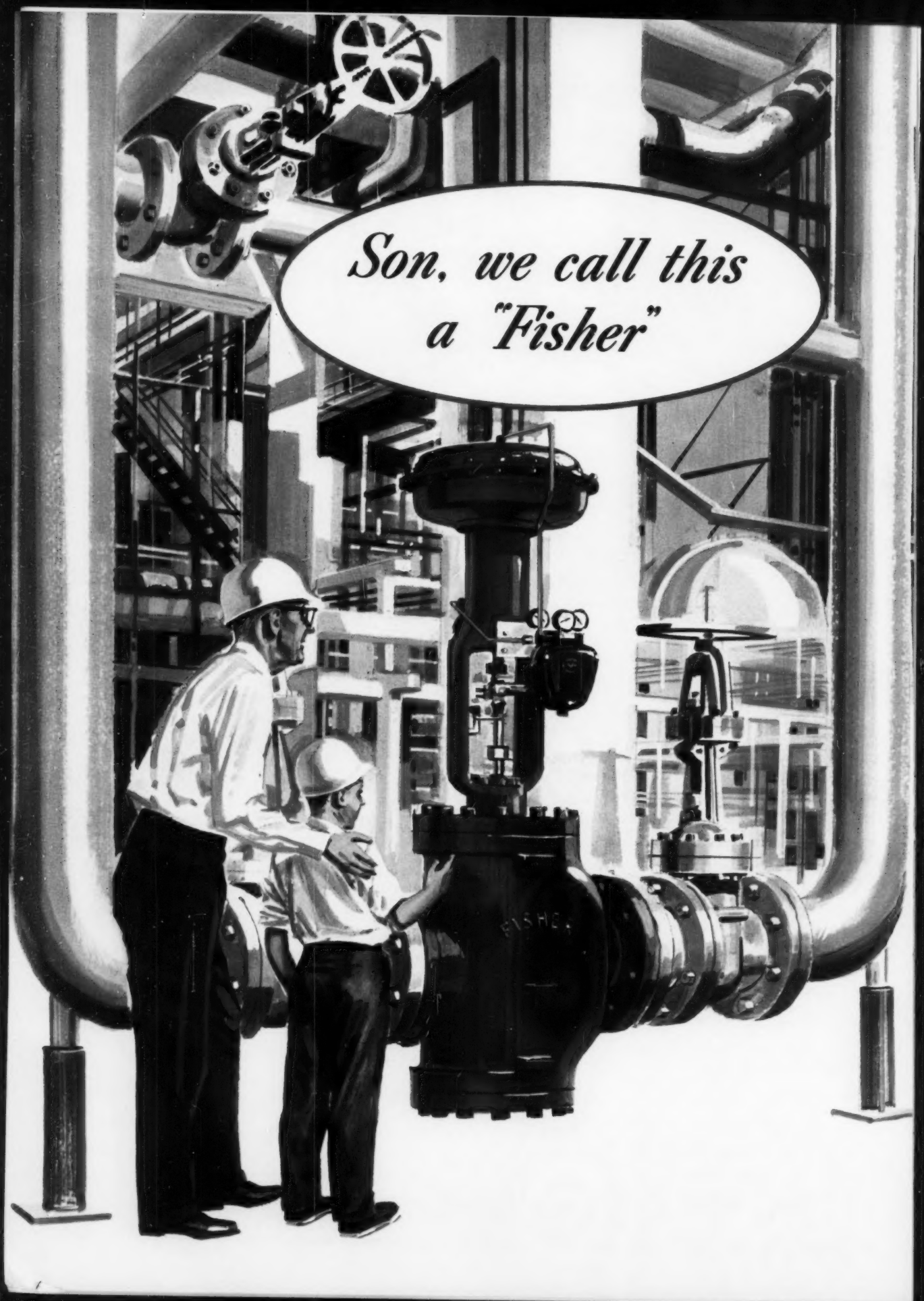
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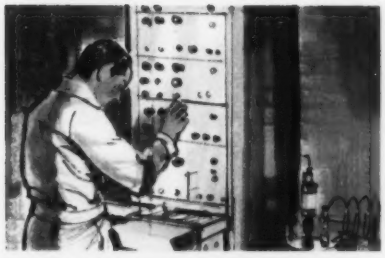

Continuous Advanced Research . . . Fisher research maintains a continuous program for development and use of new metals and materials to meet the increasingly severe conditions, encountered daily, in the nuclear and cryogenics fields.

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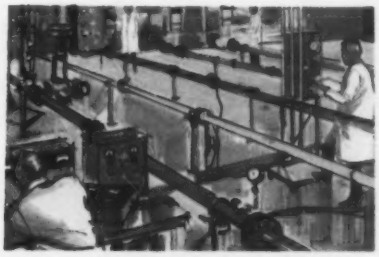
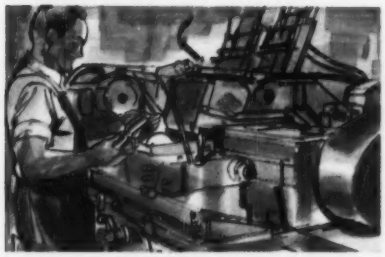
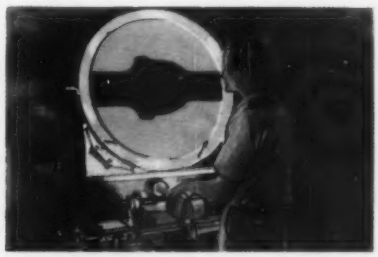


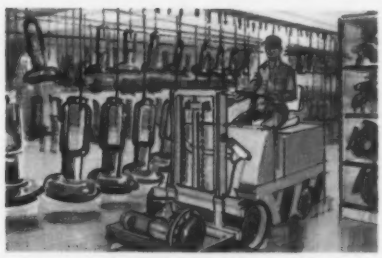
Testing and Development . . . Representative of the very latest and finest in equipment that aids Fisher engineers in the development of new and improved products is the recent addition of a test line that is capable of handling air or water pressures up to 2,500 psi.



Latest Production Methods . . . Various new style grinders produce a super-finish on Fisher valve guides and bushings, second to none in the industry. It is typical of precision manufacturing methods that assure long, trouble-free operation of Fisher controls.



Rigid Inspection Procedures . . . The highest ratio of inspection personnel to production personnel in the industry is maintained at Fisher. As an example, there are no less than 704 inspection operations on a 4" Type 657-A diaphragm control valve.



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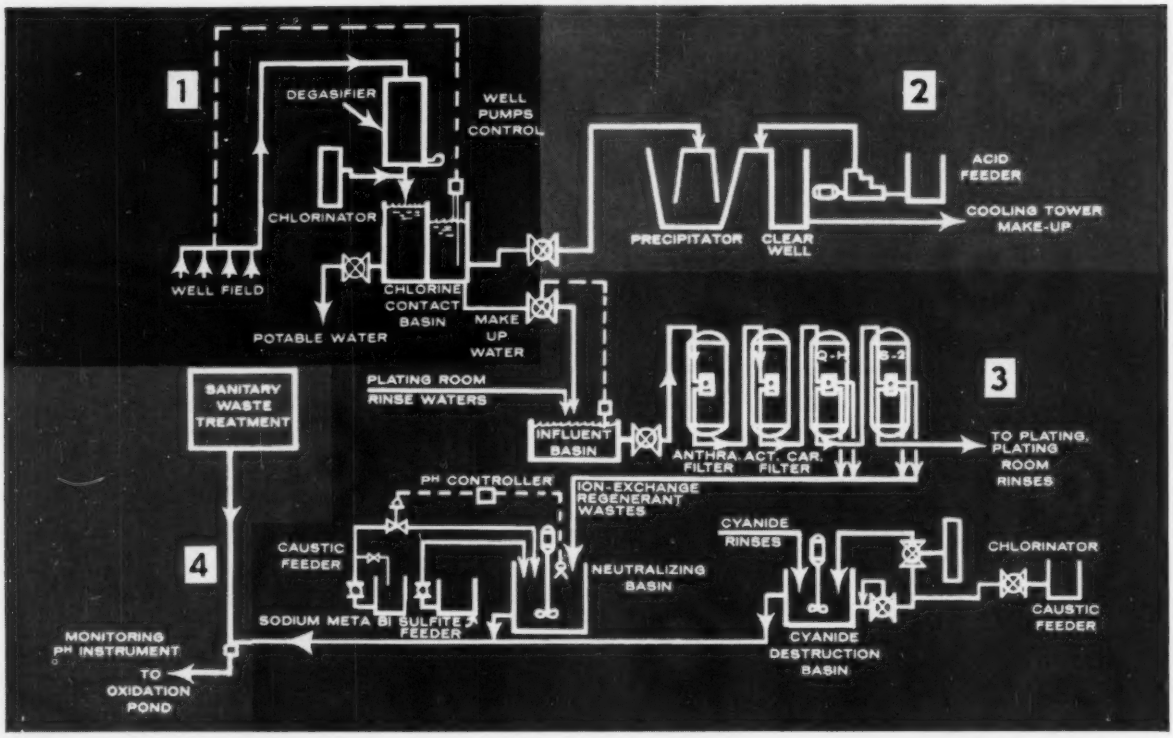

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From water source to waste disposal this new system now serving the Electro-Mechanical Research Company, Sarasota, Florida, is packed with ideas that can help *you* solve similar problems—and each idea was brought to reality with equipment supplied by Permutit.

1. Well-water treatment (upper left in diagram) handles a minimum flow of 160 gallons per minute from a well field—84 gallons for industrial cooling, 10 gallons for plating rinse make-up, and the balance for potable use. All this raw water is degasified and treated in a Permutit equipment system.

2. Cooling water undergoes further treatment (top right) for reduction of carbonate and bicarbonate alkalinity, by means of a Permutit® Precipitator and acid feeder.

3. Plating room rinse-water demineralizing (center and lower right). A complete Permutit system saves water, saves heat, treats regenerant wastes, and provides high-quality demineralized water for plating rinse. Make-up and plating rinse water is processed through an anthracite filter to remove suspended solids, a Carbo-Dur filter to remove organics, a Permutit Q-H cation exchanger, and a Permutit S-2 anion exchanger. This demineralized water is then ready for use. After plating rinse operations, water is recycled, treated and re-used. Wastes —including cyanide rinses, regenerants, and others—are batch treated.

4. Sanitary waste treatment (lower left) was designed to handle 20,000 gallons per day, treating them first in an Imhoff tank, followed by high-rate bio-filtration, secondary clarification and chlorination.

The entire system was engineered by Smally, Wellford and Nalven, Sarasota, Florida. We can cooperate with your engineering consultants to help you obtain similar results. Talk it over with them, or write for our Bulletin 4433, "Water Treatment Equipment," and/or Bulletin 4486, "Equipment for Treating Industrial Wastes."

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LEEDS & NORTHRUP CO., manufacturer of automatic controls, measuring instruments and furnaces, has advanced five men in its management personnel section. **Donald E. Moat,** vice president and director of marketing, has been elected vice president, government and foreign relations. **John F. Quereau,** vice president and director of manufacturing, has been named vice president and director of marketing. Other promotions include: **Elwood F. Rogge,** director of manufacturing; **J. Frederick Schock,** a local manager; and **William M. Feeley,** manager, Plant Engineering and Services Division.

U.S. INDUSTRIES, INC., Southern Pipe Division, has elected **Charles E. Lamar** executive vice president. Lamar joined Southern Pipe in 1951 as a sales engineer. He became a sales representative the next year and was made assistant sales manager in 1957. In 1959 he became division director and in 1961 was appointed vice president, marketing.

INLAND STEEL CONTAINER CO. has made **William E. Geidt** marketing manager. Geidt was in the Strip Steel Sales Division of Inland where he was assistant manager since 1958.

KAISER STEEL CORP. has named **Donald W. Keirn** assistant manager of plate, structural and bar sales. Keirn has been with Kaiser's sales force since 1954 and has been sales representative with southern district sales, Los Angeles, since 1957.

MANNING, MAXWELL & MOORE, INC., has appointed **F. T. Sherwood** general sales manager. Sherwood, who joined the company in 1939, was previously general manager and a vice president, Manning, Maxwell & Moore of Canada, Ltd.

CONSOLIDATED SYSTEMS CORP. has named **Allen J. Gardenhour, Jr.,** northern regional manager. Gardenhour was engineering representative in the Washington, D.C., area.

KOEHRING DIVISION, Koehring Co., has made **Charles E. Petot** district representative for Kentucky, Ohio, Indiana and Michigan. Petot, who was a salesman with Equipment & Supplies, Inc., will headquarter at Cleveland, Ohio.

GENERAL BLOWER CO. has appointed **Folger H. Bigelow,** Atlanta, Ga., sales representative. Bigelow has been with General Blower's parent company, Ilg Electric Ventilating Co., for 23 years.

ROCKWELL MANUFACTURING CO.'s Edward Valves subsidiary has added **Robert C. Hicks** to its sales staff covering West Texas, including the Panhandle, and Southeastern New Mexico. Hicks has been working the Chicago and Northern Indiana sales territory.

ALLOY TUBE DIVISION, Carpenter Steel Co., has appointed **Walter A. Baumstark** sales manager. A 15-year employe of the firm, Baumstark was midwestern regional sales manager of the division for the past eight years.

ROCKWOOD SPRINKLER CO. has named **Harry M. Goodchild** assistant general manager. Goodchild comes to Rockwood from Bellofram Corp., Burlington, Mass., where he had been general manager for the past year.

TRANS-PLASTICS CORP. has been formed in Cleveland, Ohio, to provide process industries with design, development and fabrication of corrosion resistant systems and components. The company also handles pipe, pipe fittings, sheet and tube. Heading the new firm are **Reuben Hitchcock,** president, and **Ted R. Stevenson,** vice president.

Hitchcock

Stevenson

GRAY BIMETALLIC PIPE PROVIDES CORROSION RESISTANCE AT FRACTION OF THE COST OF SOLID ALLOY SYSTEMS

Gray Bimetallic pipe provides all the fabrication and strength advantages of carbon steel with the corrosion resistance of the best alloy materials, and at a fraction of the cost of a solid alloy system.

In the Gray process, a seamless lining is hydraulically expanded into the base pipe, forming a tight bond due to differential contraction of the materials. For all practical purposes the bond is permanent. Bimetallic pipe can then be fabricated almost as easily as carbon steel. It can be butt welded, flanged and bent without damage to the lining or the bond.

The choice of materials for Bimetallic pipe is virtually unlimited. Base material is usually standard carbon steel in regular sizes and schedules, but this can be varied to meet any particular need. Linings are most frequently furnished in Monel, nickel and stainless steel, but the selection is in no way limited. All the alloys of nickel and copper as well as the reactive metals can be economically produced.

This wide range of materials available make Bimetallic pipe ideal for all applications where corrosion is a factor. It is well suited where product contamination or catalyst poisoning are problems.

Gray Bimetallic pipe provides the corrosion resistance of special alloys at only a small cost more than that of regular carbon steel piping. For complete details, mail the coupon below today!

GRAY Tool Company

P. O. Box 2291 • Houston 1, Texas

Gray Tool Company
P. O. Box 2291
Houston 1, Texas

Gentlemen:
Please send me more information about Gray Bimetallic pipe.

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

6114

Suppliers . . .

GENERAL PRECISION, INC., Librascope Division, has appointed **John R. Harkness** vice president, marketing. Harkness, who was manager, electronics, Bendix-Pacific Division, joined the firm in 1959.

EBASCO SERVICES, INC., has named **Hermann F. Bottcher** director of manufacturing and operations services, Management Consulting Division. He succeeds **John D. Cassidy,** who has been appointed director of industrial management consultation.

BAILEY METER CO. has named five men to direct its engineering departments: **A. J. Hornfeck,** director of research; **J. E. McEvoy,** manager, Product Engineering Department; **R. E. Clark,** head, Equipment Engineering Department; **J. K. Loeser,** chief, Project Engineering Department; and **J. V. Werme,** manager, Electrical Engineering Department.

OKONITE CO. has appointed **Dr. Robert B. Blodgett** director of research. Blodgett has been a member of Okonite's research staff since 1954.

GOLDEN-ANDERSON VALVE SPECIALTY CO. has elected **John H. Kilmer, Jr.,** president and general manager. **Grant A. Colton** is vice president and chairman of the board.

OTTAWA CHEMICAL CO. has named **William C. O'Brien** sales manager. O'Brien will handle both domestic and foreign sales for Ottawa.

ACME INDUSTRIES, INC., has appointed **Russell E. Brant** manager, special heat exchanger products. Brant has worked 10 years in the heat transfer and fluid flow fields.

CORNING GLASS WORKS has made **Robert J. Hull** supervisor of customer service, central sales district, Technical Products Division. Hull, who has been with Corning since 1957, will headquarter in Chicago.

CATALYTIC CONSTRUCTION CO. has promoted **Richard P. Klopp** from general sales manager to vice president, sales, and a director. Klopp, who joined Catalytic in 1952 as a chemical engineer, was made general sales manager in February 1961. He has worked in process and project engineering, project management and was Gulf Coast area sales manager and manager of commercial sales. He is a graduate of Cornell University with a degree in chemical engineering.

Klopp

GENERAL BLOWER CO. has named **Joseph H. Maloney** and **Sidney C. Shepard, Jr.,** sales agents for Louisiana, lower Mississippi and the Florida Gulf Coast areas. General Blower is a division of Ilg Electric Ventilating Co.

ANDREW DOSSETT IMPORTS, INC., Los Angeles, has been appointed exclusive U.S. agents for Kobe Seiko, Ltd., Japanese producer of copper-alloy heat exchanger and condenser tubes. Dossett specializes in importation of tubes for the process industry.

KELITE CORP., makers of industrial cleaning compositions, metal processing chemicals, and steam cleaning equipment, has elected **L. C. Sorensen** chairman of the board. Sorensen, who will continue as chief executive officer, is founder of Kelite and was president from 1937 to 1961. **William Sorensen,** formerly executive vice president and marketing director, has been named president. **Louis McDonald,** a vice president and technical director, has been made executive vice president.

CONSOLIDATED ELECTRODYNAMICS CORP., has named **Daniel E. Murphy** assistant to the president. Murphy, who joined CEC in 1958, has been general manager, Datalab Division.

CONTINENTAL-EMSCO CO.'s Oklahoma-Kansas Division has named **W. E. Lasseter** merchandise manager. Lasseter has been manager of Continental-Emsco's Oklahoma City branch store since 1959.

E. W. BLISS CO. has elected **Carl E. Anderson** president and chief executive officer. Anderson, who was also elected to

FLINT STEEL

Steelmanship☆

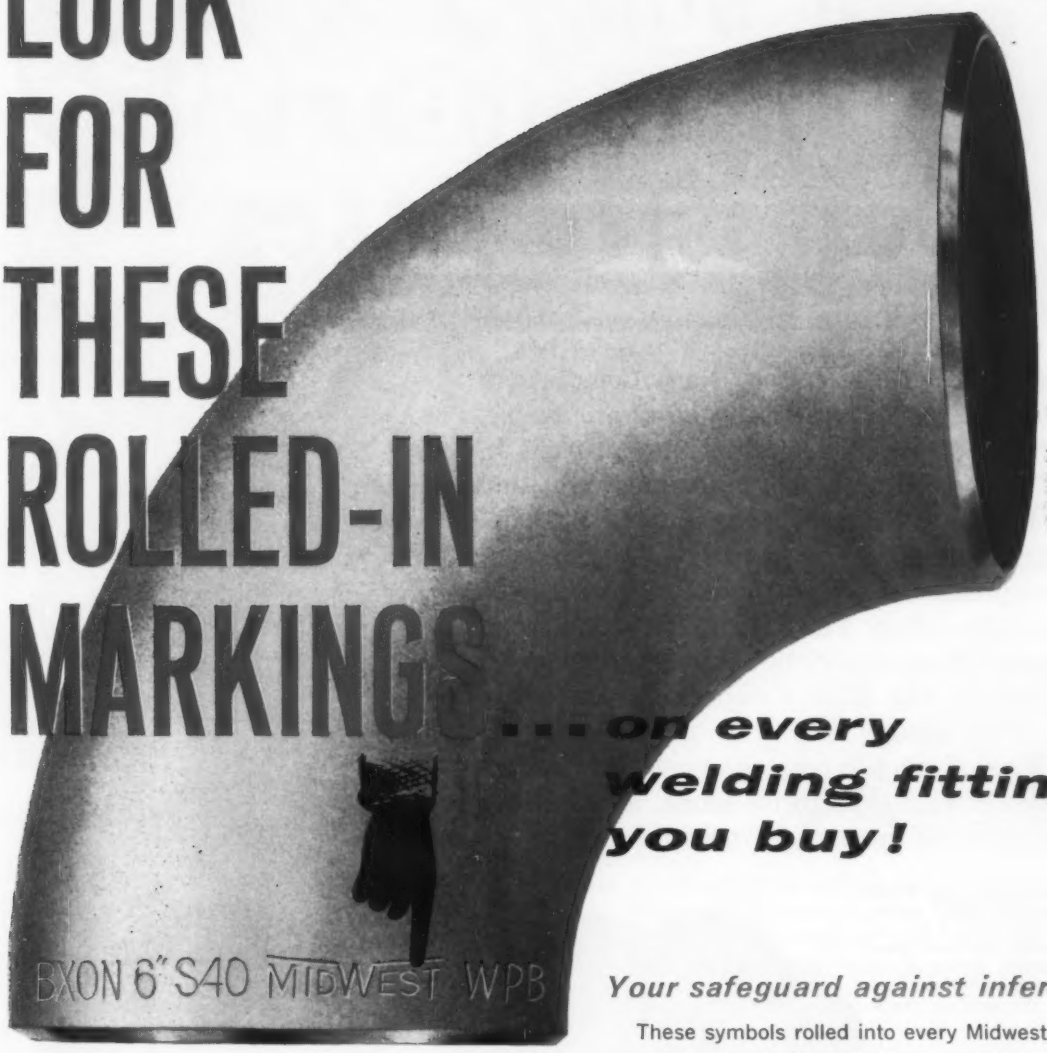
Deisobutanizer tower 9' dia. x 166' length, and eight other process vessels totaling 435 tons of plate.
FABRICATOR: FLINT STEEL CORPORATION
TULSA, OKLAHOMA

☆Superior craftsmanship in fabricating the right steel for the job, to the rigid specifications set by the customer.

STEEL PLATE FABRICATORS ASSOCIATION

FLINT STEEL CORPORATION
TULSA . . . TWX, TU-1914 . . . MEMPHIS

LOOK FOR THESE ROLLED-IN MARKINGS



... on every welding fitting you buy!

BXON—HEAT SYMBOL—Used to identify physical properties, chemical analysis of raw material, radiographic control testing, and heat treatment.

6" S40—SIZE AND WALL THICKNESS

MIDWEST —TRADE MARK—Your Midwest distributor's guarantee of brand-new fittings made from prime domestic steel.

WPB GRADE OF STEEL—Your identification of the grade of steel . . . and your assurance that each Midwest fitting is made in full compliance with ASTM and ASA standards.

Your safeguard against inferior quality

These symbols rolled into every Midwest fitting are your guarantee of brand-new fittings made from prime domestic steel in full compliance with ASTM and ASA standards!

Even the markings are made with specially designed low-stress dies to preclude injury to the steel. Care such as this demonstrates Midwest's sincere determination to manufacture fittings of highest quality throughout . . . unmatched anywhere!

Write for Bulletin 60C, ONLY MIDWEST MAKES BOTH, the story of how superior quality fittings are made from either seamless tubing or rolled plate.

MIDWEST PIPING

A Division of Crane Co. / 1450 South Second St., St. Louis 4, Mo.

8124

For more data on advertised products, use cards, last page.

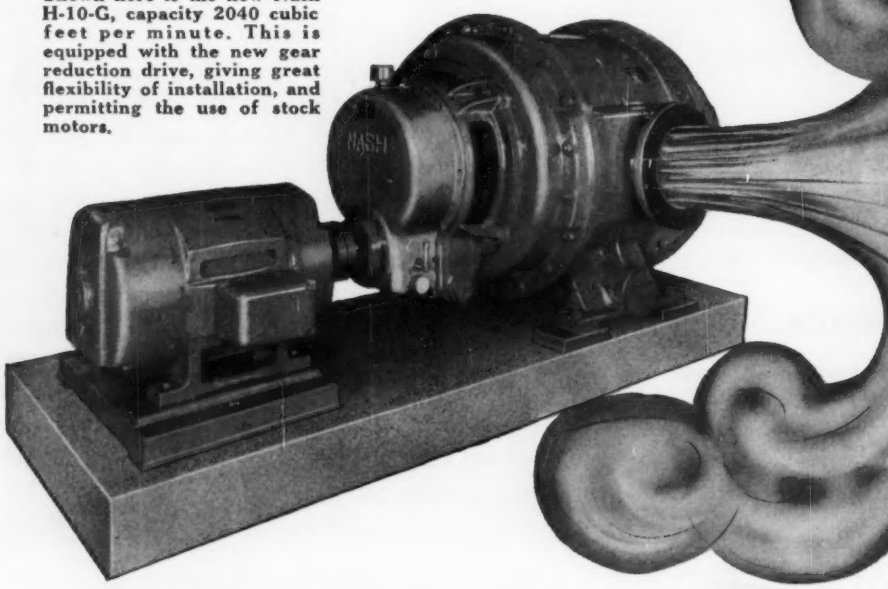
Nash Compressors Tame "Hard-to-handle" Corrosive Gases

The reasons for the success of Nash Compressors in handling "dirty" and corrosive gases are simple. First, Nash Compressors have no internal parts in wearing contact, or requiring close tolerances and internal lubrication. Second, because of the Nash operating principle, a variety of liquids can be employed as the compressant medium, protecting the interior from corrosive action. Third, the pump casing may be fabricated from a variety of special metals and alloys. That is why Nash Compressors take these rugged jobs in stride.

Nash Vacuum Pumps offer the same basic advantages when handling corrosive gases, and reliably maintain vacuums up to 29.50 inches of mercury.

ACETONE
ACETYLENE
AMMONIA
ARGON
BUTADIENE
CARBON DIOXIDE
CARBON MONOXIDE
CHLORINE
ETHYL CHLORIDE
FLUE GAS
FURFURAL
HEXANE
HELIUM
HYDROGEN
HYDROGEN SULPHIDE
NITROGEN
OXYGEN
PHOSPHOROUS PENTOXIDE
SULPHUR GAS
VINYL ACETATE
VINYL CHLORIDE
AND MANY OTHERS

Shown here is the new Nash H-10-G, capacity 2040 cubic feet per minute. This is equipped with the new gear reduction drive, giving great flexibility of installation, and permitting the use of stock motors.



NASH ENGINEERING COMPANY

SOUTH NORWALK, CONNECTICUT, U. S. A.

Suppliers . . .

the board of directors, was previously director of general management consultation for Ebasco Services, Inc. He will headquarter in Canton, Ohio.

FOXBORO CO. has elected **Charles Schwarzler** vice president, marketing.

Schwarzler

Ehrisman

Tivy

Henry O. Ehrisman has been appointed vice president and U.S. general sales manager. **Vincent V. Tivy** has been promoted to director of engineering. Schwarzler has been with the company for the past 26 years; Ehrisman joined the firm in 1936; and Tivy came to Foxboro in 1945. Foxboro's headquarters are at Foxboro, Mass.

REYNOLDS METALS CO. has named **Gilbert R. Shockley** general director, Product Development Division. Shockley was formerly vice president for metals, International Division, Olin Mathieson Chemical Corp.

SCHUTTE AND KOERTING CO. has appointed **E. C. Busfield** manager, power equipment sales. Busfield has been with the company for 25 years, beginning in its Design Division. Prior to his appointment, he was assistant manager, the firm's Valve Sales and Engineering Department.

FISCHER & PORTER CO. has named **Edgar M. Corson** director of sales, Data Reduction Division. Corson, who will headquarter in Warminster, Pa., was a national manufacturing representative for the company.

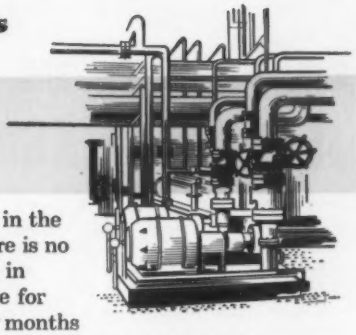
BURGESS-MANNING CO. has appointed **Jean B. Dumon** president director general of its subsidiary, Burgess-Manning, International, S. A., Paris, France. Dumon will work in Western Europe in the field of industrial silencing and pulsation dampening for the petroleum and chemical industries.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has elected **John W. Anderson** vice presi-

Positive Proof...

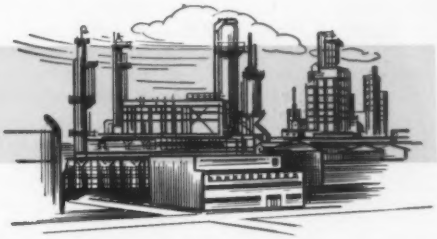
The John Crane® Type 9 Shaft Seal Solves Those Tough Liquid Handling Problems

Actual Field Reports



from an Arkansas Refining Plant

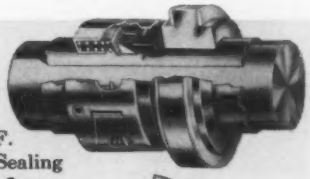
When it comes to avoiding trouble in the handling of naphtha at 420°F., there is no substitute for positive sealing. And in cases like this there is no substitute for "John Crane's" Type 9 Seal. Many months of completely satisfactory operation offers convincing proof.



from a Louisiana Refinery

It takes a "lot of shaft seal" to handle a highly corrosive mixture such as an emulsion of sulphuric acid and butane. This stuff plays real havoc with metals due to its corrosive action. Despite this, Type 9 Seals on twenty seven pumps are pumping month after month in continuous service. At this same location, other Type 9's are effectively handling "fresh" sulphuric acid at the high suction pressure of 400 psi.

In cases like these . . . and in those confronting you . . . the surest answer is the "John Crane" Type 9 Seal.



CONDENSED SPECIFICATIONS

Recommended services: all industrial chemicals, corrosives, liquids or gases. Temperatures: −120°F. to +500°F. Pressures: up to 750 psi. Construction: Sealing members of chemically inert DuPont Teflon, metallurgy best suited to service requirements.

Send us your problems. Request Bulletin S-205-2.

Crane Packing Company, 6420 Oakton Street, Morton Grove, Illinois, (Chicago Suburb).
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John Crane

MECHANICAL PACKINGS

SHAFT SEALS

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LAPPING MACHINES

THREAD COMPOUNDS

CRANE PACKING COMPANY

Lock your Hazards in a SOLID-WALL CHAMBER

and Gage Safely and Accurately with JERGUSON MAGNETIC GAGES

Jerguson Magnetic Liquid Level Gages give you accurate liquid level and interface readings . . . with absolute safety . . . when you're dealing with problems of dangerous liquids, toxic gases and corrosion. You eliminate the dangers inherent in glass and its gaskets, and in threaded connections . . . for you lock your hazards in a solid-wall chamber, flanged to the vessel being gaged.

Indicator Operated Through Chamber Wall

The unique design of the Magnetic Gage places a float with an actuating magnet inside a sealed chamber and an indicator mounted outside the chamber. The indicator is magnetically operated *through* the chamber wall. The chamber is completely sealed so there is no danger of gases or fluids escaping.

The level indicator consists of edge-magnetized wafers which rotate. As liquid levels change, an accurate reading is shown as a red column contrasted with silver above.

Four Models; Job Correlated

Jerguson Magnetic Gages are available in four models to fit a variety of installation needs. The float is adjusted for specific gravity and correlates pressure, temperature and specific gravity.

In Use on a Variety of Liquids

Many prominent Chemical and Petrochemical Companies have installed these Magnetic Gages for liquid level or interface reading. They will handle any liquid, and are in such varied services as: many hydrocarbons, including lube oil, ethyl mercaptan, etc., alcohol, ammonia, hydrofluoric, sulphuric and other acids, liquid nitrogen, caustic soda, high-pressure feed water and many others.

Why invite expense and danger when you can eliminate your hazards with this safe, accurate Magnetic Gage?

Investigate now. Get full details about this unusual, accurate and safe gage. Ask for the complete new Magnetic Gage catalog.

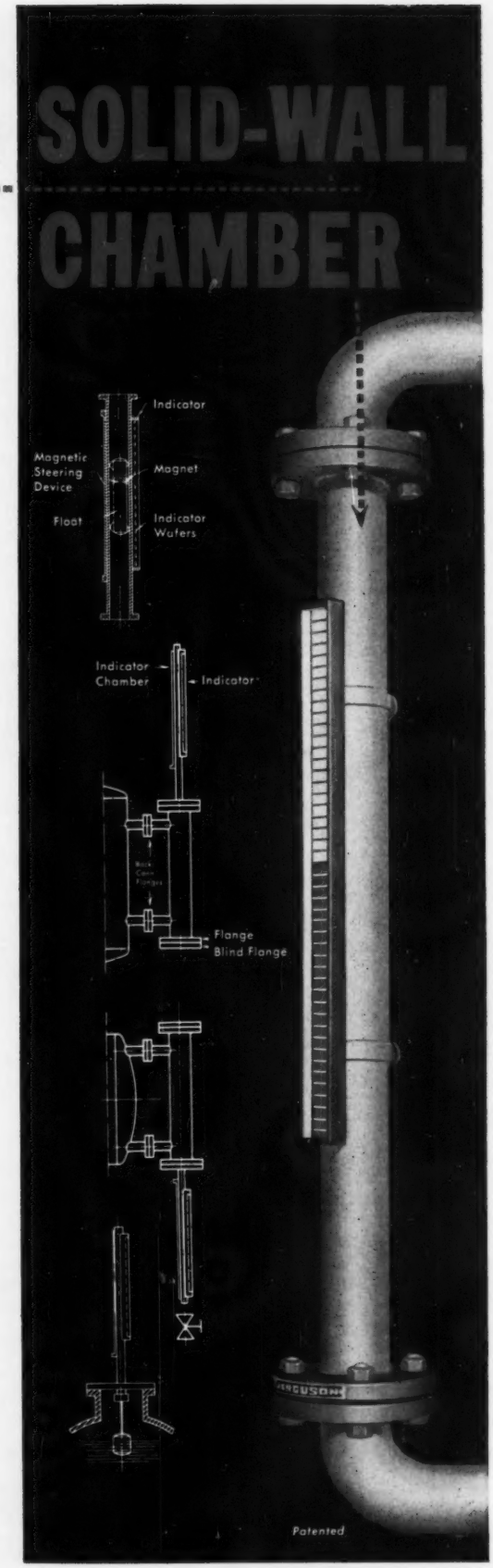
Jerguson serves with:

Reflex Gages	Heated Gages
Transparent Gages	Welding Pad Gages
Tubular Gages	Magnetic Gages
Non-Frosting Gages	Liquid Level and
Large Chamber Gages	Instrument Valves

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY
100 Adams Street, Burlington, Mass.
Offices in Major Cities



Suppliers . . .

dent of engineering, Electronic Data Processing Division. Anderson, formerly manager of Honeywell's inertial guidance plant at St. Petersburg, Fla., replaces **J. Ernest Smith,** who has been named vice president, Electronic Data Processing Division.

AMERICAN METER CO. has elected **Dante E. Broggi** director. Broggi is also vice president of the firm, which makes precision measurement and control equipment for the gas industry. Before joining American Meter in 1958, Broggi was president and director of Neptune Meter Co.

JONES & LAUGHLIN SUPPLY DIVISION has promoted **J. W. Crownover, Jr.,** from

Crownover

Crawford

Smith

store manager at Worland, Wyo., to district store manager, Odessa, Texas. **J. J. Crawford,** formerly store manager at Liberal, Kan., has been appointed district store manager at Borger, Texas. **Evan Smith** has been transferred from Borger, Texas, where he was store manager, to Liberal, Kan. Crownover joined the company in 1946, Crawford in 1934, and Smith in 1951.

WATUBO INDUSTRIES is the new corporate name for Water Tube Boiler & Tank Co., Chicago, designers, manufacturers and fabricators of fluidynamics equipment.

BABCOCK & WILCOX CO.'s Boiler Division has named **Seth M. Snyder** Pittsburgh district sales manager. **J. W. Thompson** succeeds Snyder as district sales manager in Charlotte, N.C. **J. E. Roberson** has been transferred from the Atlanta, Ga., sales office to replace Thompson as sales engineer in Cincinnati, Ohio.

SECURITY VALVE CO. has elected **Robert Linquist** vice president of engineering. Before joining Security, located in South Pasadena, Calif., Linquist was chief engineer at Annin Co. Security, a subsidiary of Menasco Manufacturing Co., is in design, development and manufacture of

SAVE up to 20% in over-all installation costs WITH BUFNEL GRIPSTEEL

the improved Surface Armor for reinforcing and retaining castable linings.

Unique design brings you these exclusive advantages:

- **LANCES** — Two internal lances in each hex reinforce and lock castable positively in place.
- **LARGE GROUT HOLES** — Permit easier flow of liner material and produce stronger bond.
- **ELONGATED HEXES** — Permits easier installation of liner material and more uniform lining.
- **LIGHTER WEIGHT** — The greater retentive properties of Gripsteel result in lower steel-to-castable weight ratio.
- **LARGER PANELS** — Up to 5′ x 15′ — Fewer pieces to handle; economical cutting.

Please send me a free sample of Bufnel GRIPSTEEL ☐ - Steel Grid ☐ - Lance Grid ☐ and a copy of your latest technical brochure.

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MANUFACTURERS OF A COMPLETE LINE OF SURFACE ARMOR

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Elliott STANDARD ejectors available for FAST DELIVERY

For producing a vacuum, you can't beat the simplicity, dependability and low cost of Elliott steam jet ejectors. STANDARD sizes, up to 3-in. suction openings, are available for fast delivery.

For prices, contact nearest Elliott office, or write Elliott Company, Jeannette, Pa., giving application, capacity and suction pressure required, steam temperature and pressure. GI-1

ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA

PLANTS: Jeannette and Ridgway, Pa.; Springfield, Ohio

TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS • EJECTORS • STRAINERS • TUBE CLEANERS

Sizes smaller than 2" suction have screwed connections.

Suppliers . . .

precision control valves for the petrochemical and processing industries.

TRINITY EQUIPMENT CORP. has appointed **Marcel Verrando** chief engineer. Verrando had been an assistant chief engineer, Pall Corp., where he specialized in designing filtration equipment.

PFAUDLER CO., a division of Pfaudler Permutit, Inc., has named **Richard D. Kearney** product manager in charge of centrifuge sales. He will work with Pfaudler's Machinery Sales Department.

SCHUTTE AND KOERTING CO. has promoted **N. B. Hammond** to manager, process equipment sales. Hammond joined the company as a project engineer, and served as assistant manager, Jet Sales and Engineering Department, before his promotion.

RHODIA, INC., has assigned **Charles N. Lockwood** to its Sales Department. Formerly sales manager of Cloroben Chemical Corp., Lockwood will work in Rhodia's Alamask Division.

M. H. DETRICK CO. has appointed **Charles J. Hendrickson** manager of national accounts, Insulation Division. He will headquarter at Detrick's New York office.

THE LUMMUS CO. has appointed three sales engineers to expand its senior

Cornforth

Ramer

sales force. The appointees are: **Robert M. Cornforth,** Lafayette, Calif., formerly national sales manager for Information Systems; **Marvin M. Ramer,** Pittsburgh, district manager of Blaw-Knox Co.; and **John J. Schottinger,** La Mirada, Calif., a project manager for Ralph M. Parsons Co. All the men will make their headquarters at Lummus' main office in New York City.

Schottinger

A. P. GREEN FIREBRICK CO. has elected **J. James Offutt** executive vice president. Offutt has been vice president and general manager for sales, research and operations. He became a vice president in January 1958 and later was made director of sales.

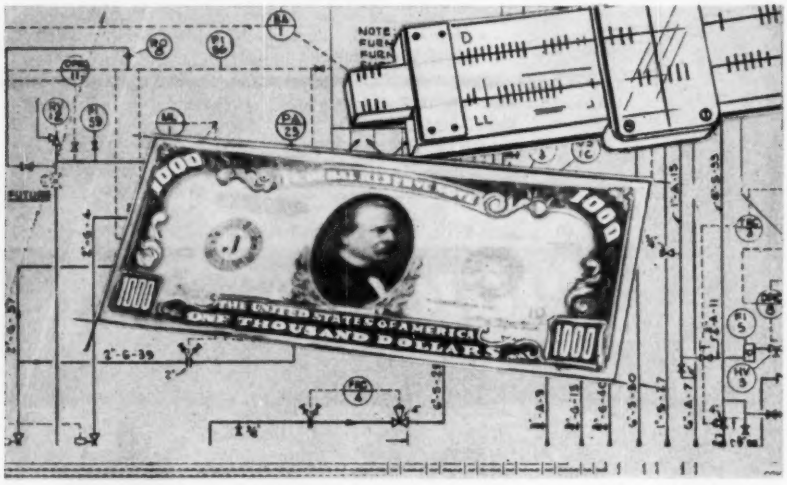
BRIDGEPORT BRASS CO. and National Distillers and Chemical Corp. have merged. Bridgeport Brass, a producer of mill and fabricated products of non-ferrous metals, has become an operating division of National Distillers.

UNION PUMP CO. has promoted **William A. Stevens** to manager of marketing. He will handle all sales functions, including sales promotion and marketing services. Stevens joined Union Pump in 1946 as a product application engineer.

SNAP-TITE, INC., has named **Paul B. Roberts** manager, Midwestern Division. Roberts, who will direct sales in Chicago and the Midwest, succeeds **L. R. Finn,** who has been promoted to assistant sales manager at the firm's home office in Union City, Pa.

DURALOY CO., producers of static centrifugal and shell-molded high alloy castings, has opened a sales and engineering office at 4101 San Jacinto St., Houston.

GOLDEN-ANDERSON VALVE SPECIALTY CO. has purchased Rotary Valve & Engineering Corp., Birmingham, Ala., designers and manufacturers of circular, full-port rotary valves and linear valves for high-pressure and high-velocity applications. The name of the company has been



Let NOFSINGER Design Your New Manufacturing Facilities for Maximum Operating Profits

Nofsinger, with a staff of experienced engineers, offers consulting, process, project and design engineering, procurement and construction services for your complete project.

You can count on dependable results from Nofsinger's friendly and effective hard-hitting organization.

Your operating profit is of major concern to us, as that is the fundamental basis for your success. Continuing repeat business is our aim and the only way we can succeed.

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Engineers and Contractors for the Petroleum and Chemical Industries

307 East 63rd Street **Kansas City 13, Missouri**

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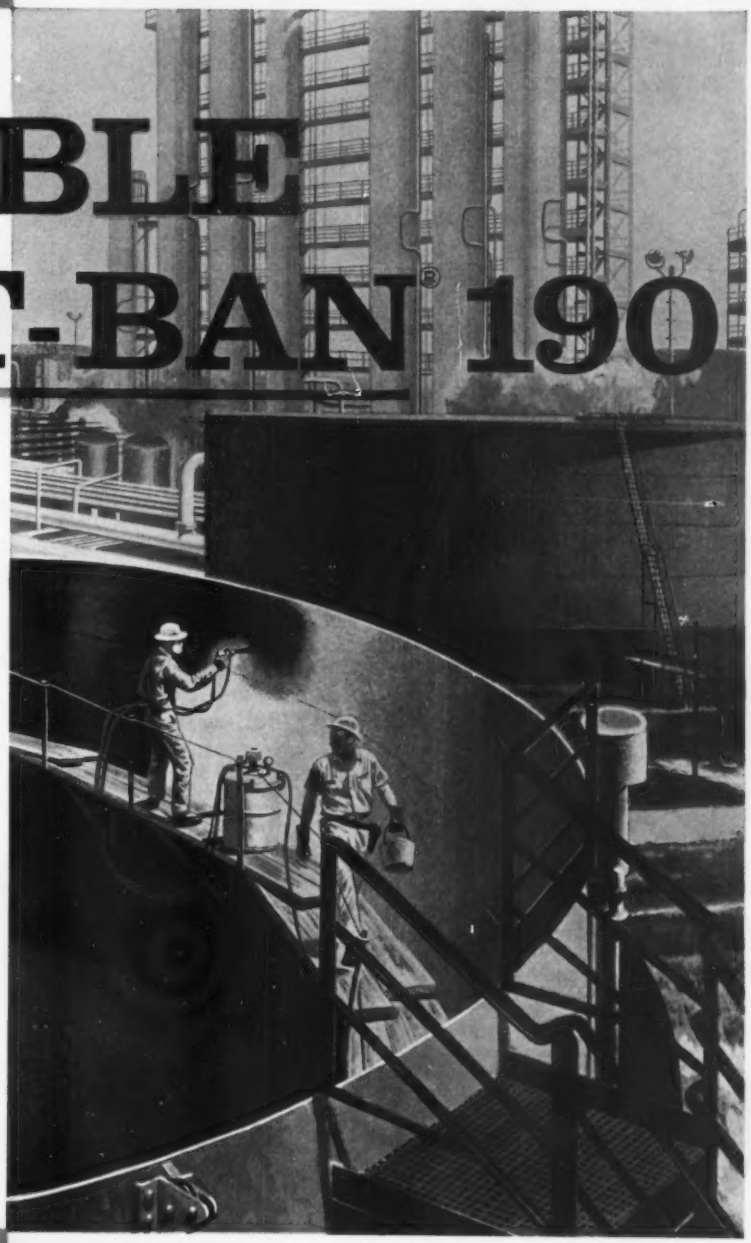
REACTS WITH THE STEEL...

...eliminates underfilm corrosion in finished product tanks

HUMBLE RUST-BAN® 190



This remarkable new coating bonds so perfectly to steel that you cannot discover an interface! The reason? *RUST-BAN* 190 reacts *chemically* with the steel. The resulting bond is inseparable . . . completely eliminating underfilm corrosion.

The hard, abrasion-resistant coating of 100% inorganic zinc silicate is virtually impervious to the scraping action of floating roofs. RUST-BAN 190 is nonflammable, does not contaminate even high-purity products.

When properly applied and cured (with its companion RUST BAN 195) RUST-BAN 190 provides many years of protection at far lower annual cost.

For complete information about RUST-BAN 190 and other Humble protective coatings, call your Humble salesman or contact Humble Oil & Refining Company, Houston, Texas.

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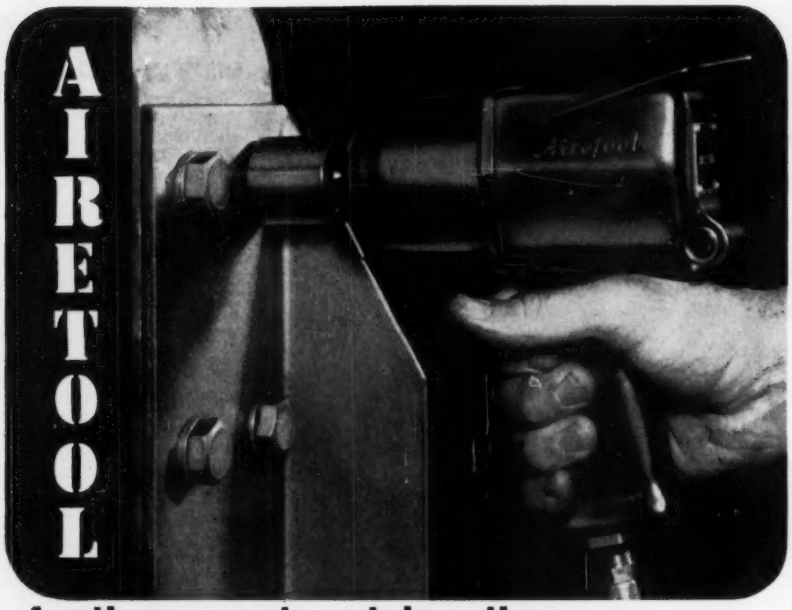


for the power to cut downtime and maintenance costs

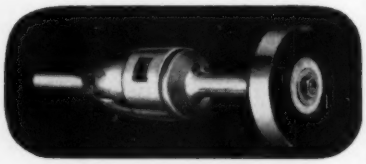
Keep your equipment in service longer with Airetool air-powered production and maintenance tools. And . . . when necessary for a complete tear down . . . Airetool gets equipment back into service faster. For example, Airetool's two new series of high-speed impact wrenches with ¼" and ½" bolt capacities . . . step up assembly operations. Minimum torque reaction makes them easy to handle and cuts operator fatigue.

NEW AIRETOOL PNEUMATIC SCALER

scales, peens, beads, star drills . . . ideal for removing weld spatter, rust and paint. Lightweight, easy-to-handle . . . 11 inches long and weighs 4 pounds. Controlled operation up to 4600 blows a minute.

GRINDERS

horizontal and vertical, air-driven grinders for heavy-duty grinding and metal removal and fine metal finishing. Muffled motors that do not reduce power.



DRILLS

powerful pneumatic drills for every need. Heavy-duty pistol-type and angle head.

Write for full information on all pneumatic production tools.

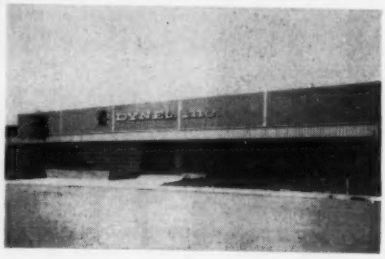
Better yet, call your local Airetool representative for a free in-plant demonstration of our complete line of tools . . . you'll find him in the Yellow Pages.

More than 30 years' experience in pneumatic tools

Representatives in principal cities of the free world

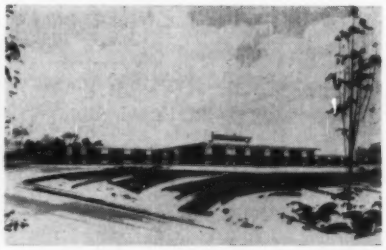
Suppliers . . .

changed to Rotary Valve Corp. It will operate as a subsidiary of Golden-Anderson.



A new 18,000-square foot facility has been completed at Los Angeles for Dynel Inc., specialists in the production of electro-mechanical controls for the petroleum, chemical and petrochemical industries. Dynel is a division of Varec, Inc.

Crane Packing Co.'s Mexican subsidiary, Industrias John Crane de Mexico, S.A., has been set up to make industrial sealing products, including mechanical packings, shaft seals and pipe thread and gasket compounds. Crane's home offices are in Chicago.



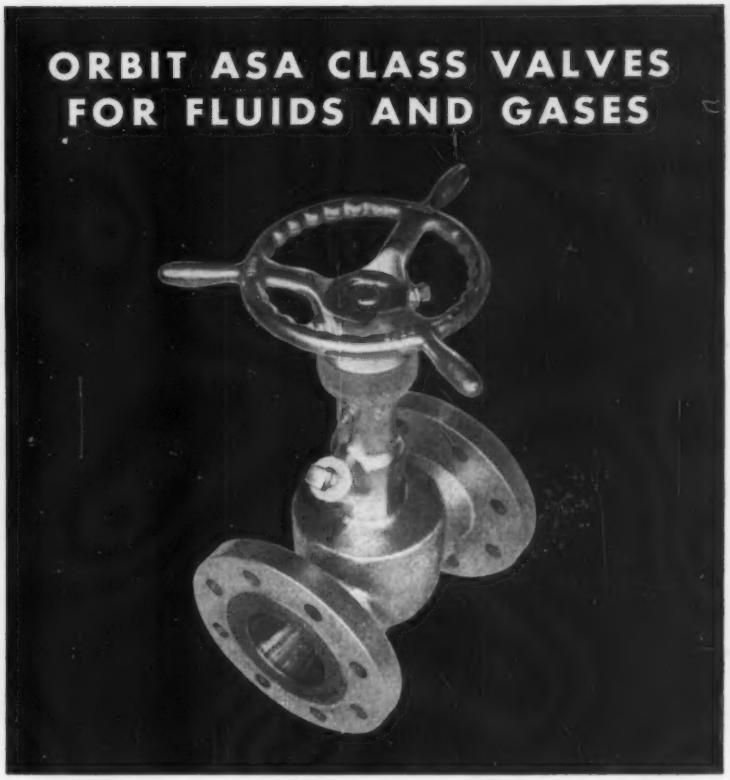
Jamesbury Corp. has let a construction contract for this 87,000-square-foot plant to be built at Worcester, Mass. The building, which is expected to be complete by November 1961, will cost an estimated $600,000.

ROCKWOOD SPRINKLER CO. has named **William J. Carroll, Jr.**, sales manager, Fixed Piping Protection Department. Carroll has been with Rockwood since 1945. He worked in the Sprinkler Engineering Department until 1946, when he was transferred to the New England Sprinkler Sales Department.

CHICAGO BRIDGE & IRON CO. has appointed **Geraldo O. Penna** director of

Sectional view of Orbit's Type "N" seat shows how we securely contain Teflon to prevent loss of material or cold flow and how a Teflon to metal seal is provided.

ORBIT ASA CLASS VALVES FOR FLUIDS AND GASES



ORBIT COMBINES THE THREE BEST KNOWN SEATING PRINCIPLES IN ONE VALVE SEAT

ORBIT TYPE "N" BODY SEAT WITH MOLDED TEFLON* FEP RESIN PROVIDES:

(1) resilient seating with metal-to-metal back-up

(2) friction-free seating

(3) seating without lubrication

TYPE "N" BODY SEAT HAS 400° Fahr. MAXIMUM TEMPERATURE RATING.

The convex seating surface formed by the Teflon and metal provides for absolute shut-off and assures immediate contact for positive closure. The Teflon is so contained that it is not affected by high differential pressures flowing across the seat. Normal manufacturing tolerances as well as normal valve wear are compensated for by the resilient Teflon material. Solid particles, such as line scale, dryer dust, catalyst carry over, etc. do not prevent the Orbit Valve from seating properly. Orbit's Type "N" seat provides both metal-to-metal and Teflon sealing. The metal-to-metal seat, provided by tapered metal edges, is additional assurance that seating surfaces will not be lost in case of disaster by fire. Heat treated metal seat retainer holding Teflon provides durable working surfaces.

* Teflon is duPont's registered trademark for its family of fluorocarbon resins, including FEP resin.

FOR ADDITIONAL INFORMATION WRITE FOR OUR NEW CATALOG 61-B

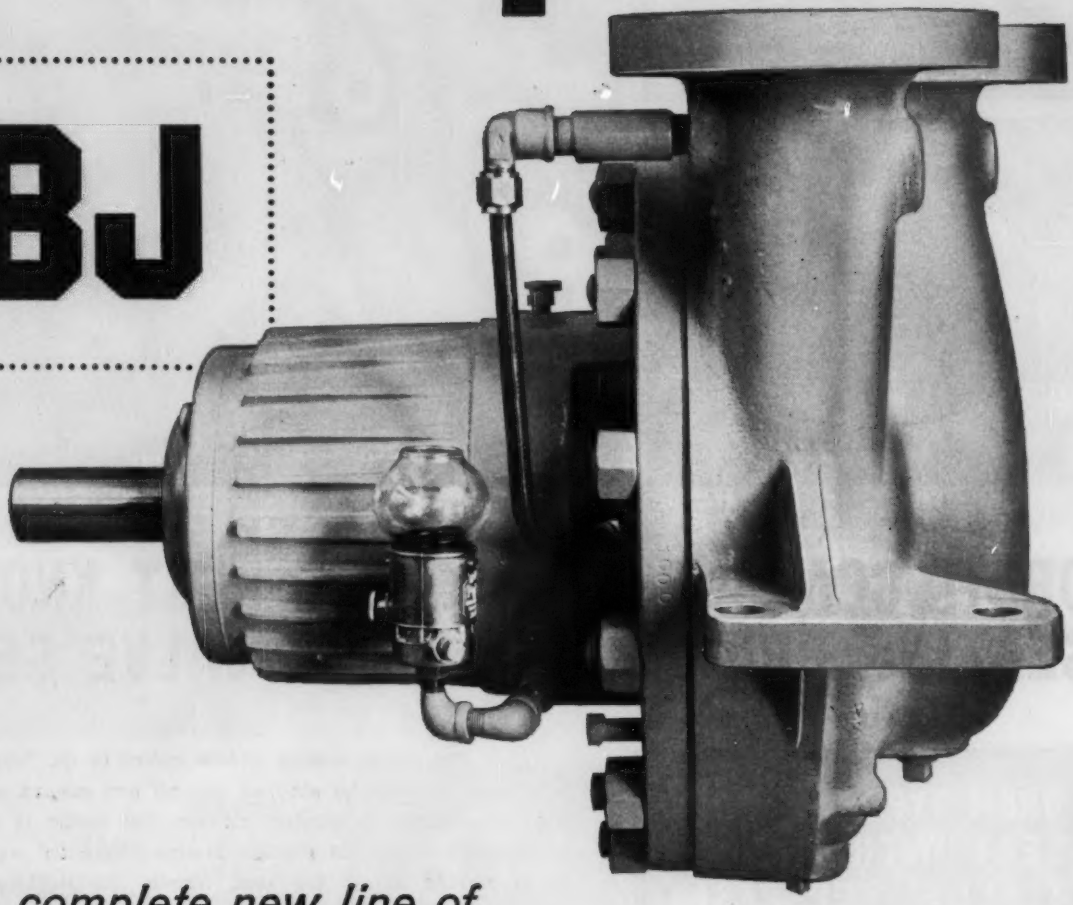
ORBIT VALVE COMPANY
P. O. Box 699 Tulsa, Oklahoma
PHONE LUther 4-4761 TWX TU 925

ORBIT VALVES

For more data on advertised products, use cards, last page.

Compact!

BJ



A complete new line of

Process Pumps

designed for maximum interchangeability

Up to 72 basic combinations of this compact new BJ Pump can provide a custom-engineered pump for almost any process pumping application—*from standard, off-the-shelf parts!*

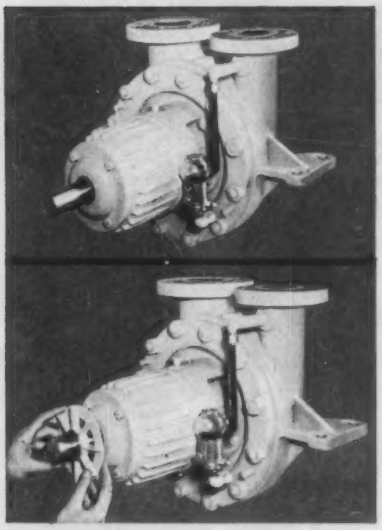
Two types, models SMJ and SMJI, offer standard stuffing box construction or an internally sealed version. With either, a choice of impellers, covers, nozzle arrangements, bearing construction, cooling methods and other components allow you to custom-engineer the pump to the job without buying features that aren't required for the service.

Also, standard, interchangeable parts simplify stocking where a number of different pump applications exist in a single plant, and the compact design saves valuable floor space when installed.

Centerline supported, single stage, the SMJ and SMJI are vertically split with either top or end suction.

Model SMJ is suited for high temperature service to 850°F, and the SMJI for a maximum of 400°F. Both are available to 1,200 gpm, and with heads to 700 feet and pressures to 700 psi!

Fan Cooled*!



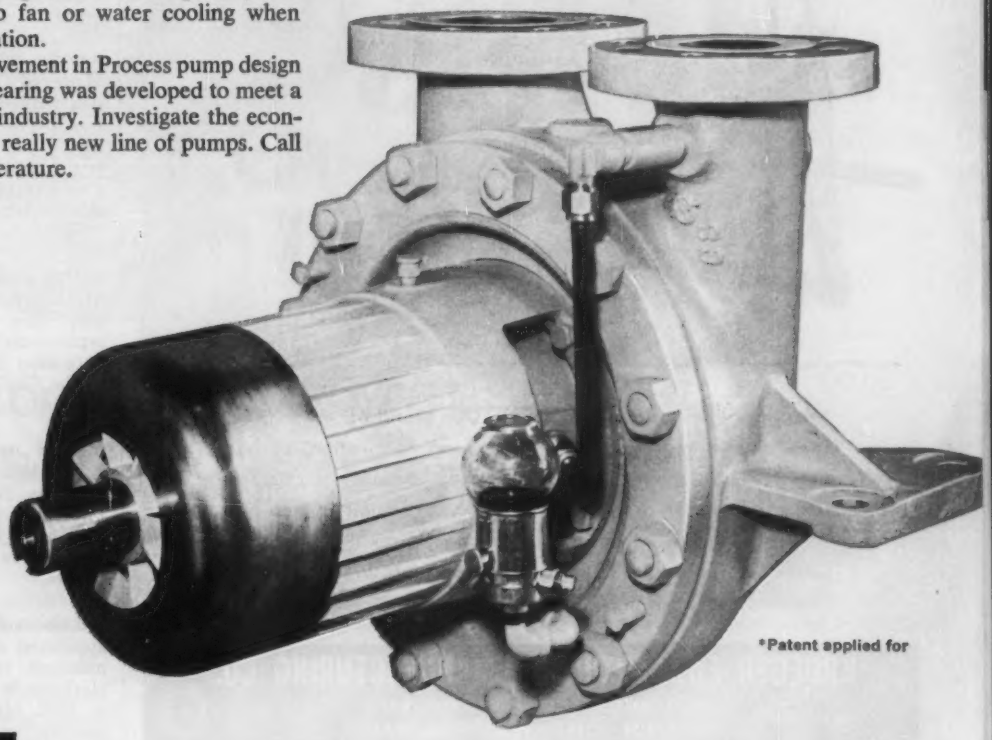
Models SMJ and SMJI Process Pumps

Now an exclusive *fan cooled* bearing housing available on Byron Jackson SMJ and SMJI Model Process Pumps can entirely eliminate a cooling water supply to the bearings! This feature was designed to eliminate engineering, installation, maintenance and operation costs of a cooling water supply, and can prevent costly freeze-ups in severe climates.

Simple, efficient and trouble-free, it works like an air-cooled electric motor. A fan mounted on the shaft behind the bearing draws cool air over the thrust bearing and out over the cooling fins of the housing. For lower temperature service the same pump can be used as a simple air cooled bearing, without the fan and fan cover, using the cooling fins alone to dissipate heat.

Only two different bearing housings fit all models of vertical SMI and SMJI's up to 300 horsepower, and either may be adapted to fan or water cooling when purchased or after installation.

As the first major improvement in Process pump design in years, this fan cooled bearing was developed to meet a long-existing need of the industry. Investigate the economy and efficiency of this really new line of pumps. Call or write for descriptive literature.



*Patent applied for

BYRON B-W JACKSON BORG-WARNER

Byron Jackson Pumps, Inc.

Subsidiary of Borg-Warner Corporation

P.O. Box 2017, Terminal Annex, Los Angeles 54, California

Suppliers . . .

sales promotion for South American operations. Penna will be in charge of an area including Argentina, Bolivia, Brazil, Peru, Chile, Paraguay, Ecuador and Uruguay. He will also continue as manager of Chicago Bridge Construcoes, Ltda., CB&I's Brazilian subsidiary.

INDUSTRIAL FILTER & PUMP MFG. CO. has named **Bruce Durham** regional sales manager. Durham will handle sales in 14 northeastern states. **Charles J. Novotny** and **Edward H. King, Jr.,** have been made sales engineers in the company. All three men will headquarter in Cicero, Ill.

DORCON, INC., a wholly owned subsidiary of Dorr-Oliver, Inc., has been formed to engage in design, manufacture, fabrication and field erection of metal tanks, water and chemical storage facilities and process and reaction vessels. **Alex Fino** is the new firm's president.

COLEMAN INSTRUMENTS, INC., has made **Charles W. Roberts** southwest district sales representative. Roberts will serve a six-state area from his Houston headquarters.

FLUOR-SCHUYTVLOT N.V., Haarlem, the Netherlands, has named **Andrew W. Ferguson** sales manager. He was sales engineer, Fluor International sales. Fluor-Schuytvlot is part of The Fluor Corp., Ltd.

MINNEAPOLIS-HONEYWELL REGULATOR CO. has appointed **Herbert J. Mulqueen** field sales manager in its Electronic Data Processing Division. He joined the Honeywell EDP Division early in 1960.

FISH ENGINEERING CORP. has elected **Don M. Simecheck** vice president of sales. Simecheck has been with Fish for the past eight years in sales engineering and the design and development of numerous hydrocarbon projects. He will be directly concerned with sales to the hydrocarbon processing industry. Simecheck, who was graduated from Oklahoma University, holds a bachelor of science degree in chemical engineering.

Simecheck

SELAS CORP. OF AMERICA has named **Charles R. Wilt, Jr.,** assistant chief engineer. Wilt joined Selas in May 1960 as assistant to the chief engineer. He was formerly with Loftus Argentina Industrial Y Tecnica, S.A., San Nichols, Argentina.

HILLS-McCANNA CO. has promoted **Richard F. Dauenhauer** from distributor sales manager to general sales manager. Hills-McCanna is a producer of ball valves, diaphragm valves, chemical metering pumps and magnesium castings.

WARREN PUMPS, INC., has appointed **Richard D. Butler, Jr.,** manager, Boston sales office. He replaces **Parkman A. Collins,** who has retired. Butler has been a sales engineer with Warren for the past seven years.

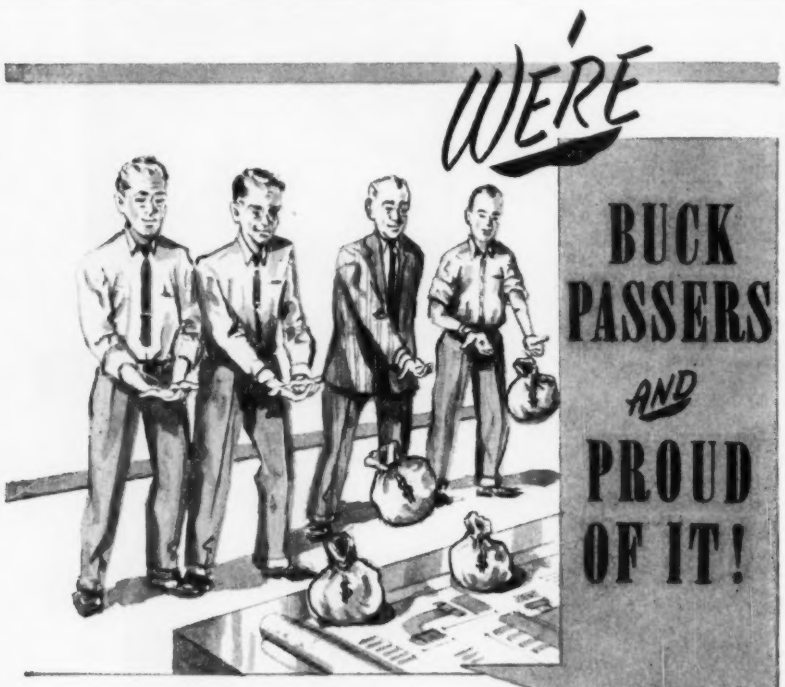
PARKER HYDRAULICS DIVISION, Parker-Hannifin Corp., has appointed **R. Gurden Miller** application engineer. Miller was previously Cleveland district manager of mobile hydraulic sales and earlier represented Parker-Hannifin industrial products in Michigan, Connecticut and Rhode Island. He joined the company in 1953.

KAISER STEEL CORP., has named **Jack D. McDaniel** assistant manager of sheet and strip sales. McDaniel, who was a sales representative with Kaiser's southern district sales, Los Angeles, will headquarter at the firm's general sales offices, Kaiser Center, Oakland, Calif.

DRESSER INDUSTRIES, INC., has elected **J. V. Holdam** vice president, electronics activities. Holdam comes to Dresser from Laboratory for Electronics, Boston, where he was a vice president. He has also been a vice president of Tracerlab, Inc., Boston.

HARBISON-WALKER REFRACTORIES CO. has appointed **Charles R. Hauth** assistant manager, technical sales. Hauth joined Harbison-Walker's Research Department in 1948. He has been in sales work for the firm in Pittsburgh and Chicago.

ALCO PRODUCTS, INC., has promoted **Arthur T. Lawrence** to manager, power and process equipment sales. Lawrence,



We specialize in design ingenuity. Our brand of ingenuity is in the custom design (and fabrication) of heat transfer equipment that does the best possible job for the least amount of money and saves you equipment "bucks." Write for illustrated brochure, personnel data sheet and customer references; let us quote your next job. We'll show you how we can pass bucks back **over** the table.

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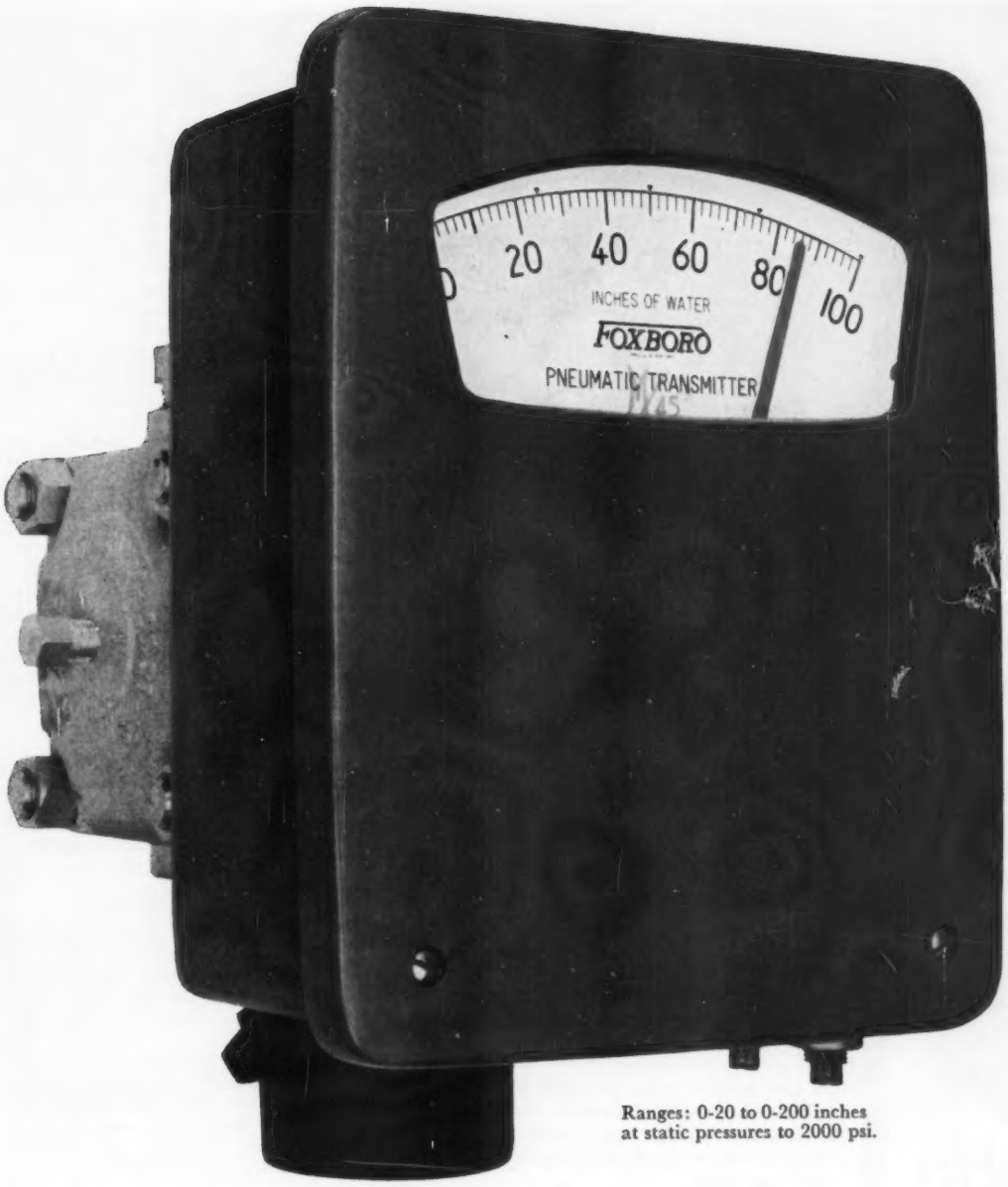

Ranges: 0-20 to 0-200 inches
at static pressures to 2000 psi.

new Foxboro Flow Transmitter continues to indicate even without air supply... needs no mercury

Here's a new indicating flow transmitter with safety built right in! Measurement indication is continuous — even if air supply fails.

Moreover, the M/45 Flow Transmitter uses no mercury in its measuring system. Instead, it uses the Foxboro Type 37 diaphragm bellows unit, which responds to differential pressure changes with unmatched sensitivity. And it cannot be damaged by overrange.

Over-all accuracy is guaranteed at ±½ of 1%; ambient temperature stability at better than ½ of 1% in 50F temperature change. Servicing is simple — zero drift virtually non-existent.

The M/45 Transmitter is also available for temperature, pressure, liquid level and dew point.

Ask your Foxboro Field Engineer for complete details, or write for Bulletin 13-30. The M/45's unmatched sensitivity — its low maintenance — make it well worth your consideration. The Foxboro Company, 749 Norfolk Street, Foxboro, Massachusetts.

FOXBORO
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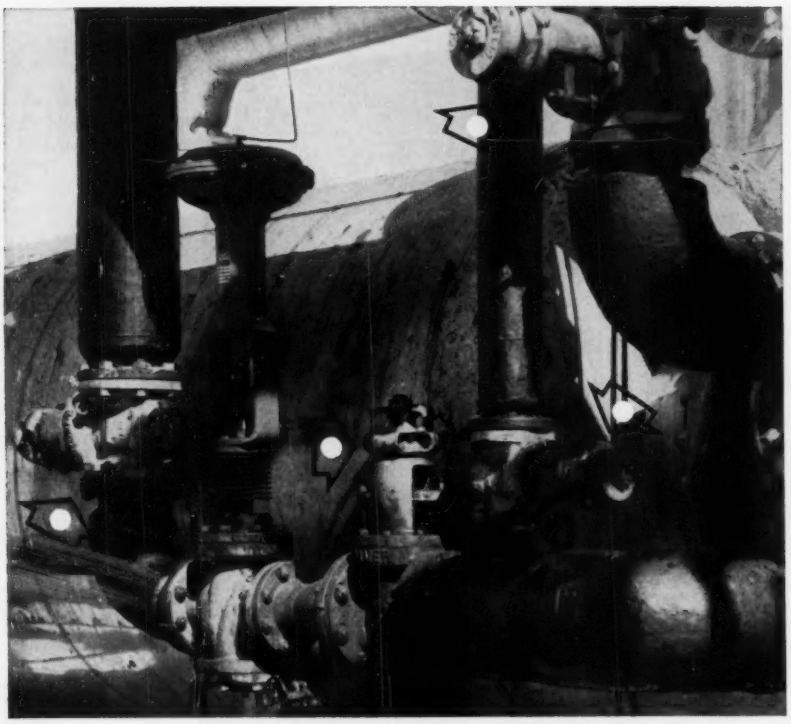
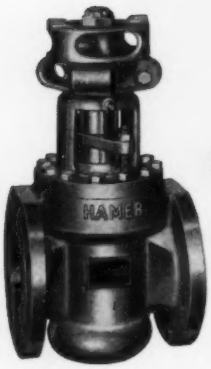
For more data on advertised products, use cards, last page.





Hamer non-lubricated, non-sticking plug valve with gland packed stem seal. Standard opening. Sizes 1" through 12", in ASA 150 lbs. and ASA 300 lbs. series. Available in carbon steel and other metals to meet special corrosive and temperature conditions.

NON-STICKING NON-LUBRICATED

Hamer Plug Valves give outstanding performance in severe services

In such services as hot oil, LPG, hydrocarbons and others where lubrication is a source of trouble and expense the non-lubricated, non-sticking features of Hamer Plug Valves prove their real worth.

Non-lubricated means there is no danger of product contamination . . . no need for lubrication and maintenance. Non-sticking means easy operation at all times under high temperatures. A powerful screwjack lifts the plug off its seat for easy opening and closing.

You can depend on Hamer Plug Valves to give maximum service with minimum maintenance. Talk to your WECO, Chiksan or Hamer valve specialists about the valve requirements in your plant, or write for new and complete HAMER Valve Catalog 60.

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Division of CHIKSAN COMPANY
a subsidiary of FMC CORPORATION

WECO UNIONS · CHIKSAN SWIVEL JOINTS · HAMER LINE BLIND VALVES · HAMER PLUG VALVES · WECO AIR-O-UNION · WECO COMPOUNDS · WECO SNATCH BLOCKS

Suppliers . . .

who joined Alco in 1932, will supervise sales at Dunkirk, N.Y.; Beaumont, Texas, and Cincinnati, Ohio, where Alco makes thermal equipment, nuclear components and petroleum industry equipment.

SAMUEL MOORE & CO. has named **Charles A. Richards** sales representative in Eastern Texas and Northwestern Louisiana. He will handle sales of instrument tubing and multiple extension wire products with headquarters in Houston.

EDWARD VALVES, INC., subsidiary of Rockwell Manufacturing Co., has named **Raymond A. Durand** vice president, sales. Durand came to Edward Valves in 1937 as a sales representative and was appointed sales manager in 1946. Edward Valves is a producer of steel valves for high-pressure, high-temperature applications in the petroleum and petrochemical industries.

PERKIN-ELMER CORP. has elected **Chester W. Nimitz, Jr.,** vice president and general manager, Instrument Division. Nimitz resigned from Texas Instruments, Inc., to accept the position. He joined Texas Instruments in 1957 after 21 years in the U.S. Navy.

METAL HOSE AND TUBING CO. has appointed **Carl E. Hopkins** chief chemist. Hopkins was previously chief chemist for Brunswick Rubber Co. Metal Hose and Tubing, a manufacturer of steel and fiber reinforced industrial and fuel hose, is a subsidiary of Dayco Corp.

HYDROMATICS, INC., has named **Madden T. Works** chief engineer for ball valve production. Before joining Hydromatics, Works was manager of operations, Turbodrill Division, Dresser Industries, Inc.

BUELL ENGINEERING CO. has named **Schaeffer E. Specht** general sales manager. Specht will supervise all sales for Buell and its Northern Blower Division in Cleveland, Ohio. He was formerly western district sales manager.

JONES & LAUGHLIN SUPPLY DIVISION has transferred **N. A. Myers,** previously at Lake Charles, La., to Lafayette, La. **G. N. Jones,** formerly at Glendive, Mont., has been assigned to Lake Charles.

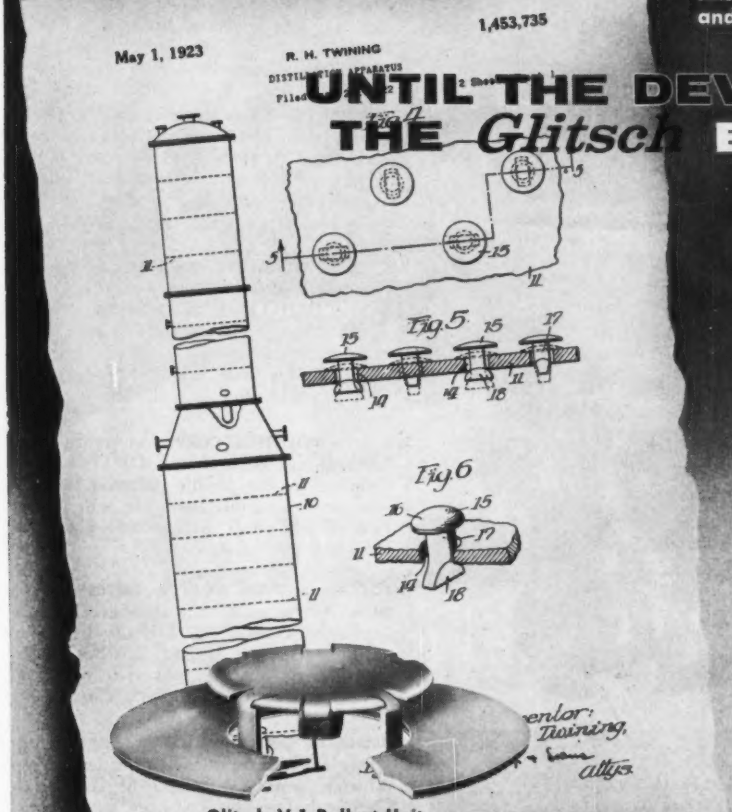
ROCKWELL-STANDARD CORP.'s industrial products group has appointed **Charles C. Warne, Jr.,** sales assistant to the vice president.

ELLIOTT CO. has named **Carlton C. Davis, Jr.,** manager, Compressor Sales Department. Davis joined Elliott in the Compressor Engineering Department in Jeannette, Pa.

BROOKS INSTRUMENT CO., INC., has purchased Francisco Engineering Co., California manufacturer of turbine-type flowmeters and mass flowmeters. Francisco Engineering will supplement

Not since 1923

when an early patent was granted covering a valve type tray—has there been any significant change or improvement in this type of tray, other than physical shape and dimensions . . .



Glitsch V-1 Ballast Unit

UNTIL THE DEVELOPMENT OF THE *Glitsch* BALLAST TRAY

. . . a two-stage vapor discharge unit that is:

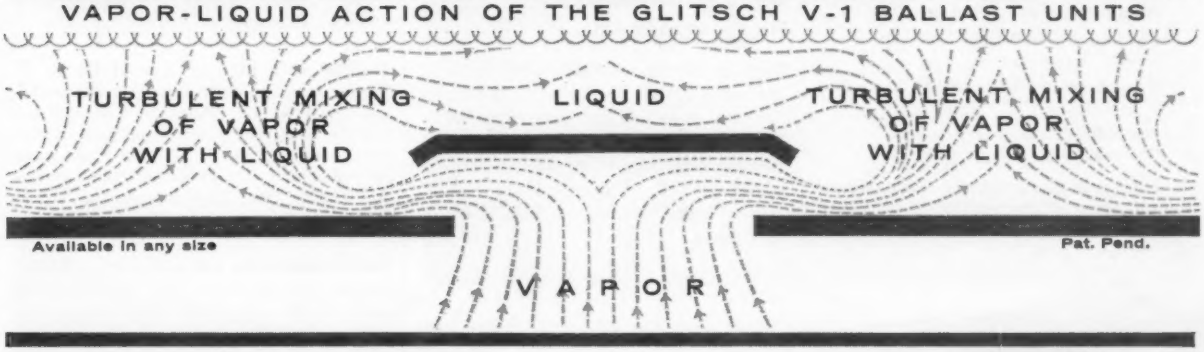
- ★ Low in cost
- ★ Low in maintenance
- ★ High in capacity
- ★ High in efficiency
- ★ High in turndown ratio

The Glitsch V-1 Ballast Unit has a single moving element with a two-stage action. The valve element positions itself initially for low to medium vapor rates and is then free to travel vertically to provide an increased orifice for very high vapor rates.

The high efficiency obtained by the Glitsch V-1 Ballast Tray is a result of the centripetal "fantail" mixing of the vapor and liquid. The vapor discharge orifice of the element is so shaped that the vena contracta at the vapor-liquid interface is amplified by the centripetal force of the vapor, resulting in extreme turbulence, greater interfacial area, and more thorough mixing of the vapor with the liquid.

For additional information on the V-1 Ballast Tray, ask your Glitsch representative for Bulletin #160. Offices in principal cities.

VAPOR-LIQUID ACTION OF THE GLITSCH V-1 BALLAST UNITS



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Glitsch "SINGLE ENGINEERING RESPONSIBILITY"

Manufacturers of Superior Fractionating Trays Since 1937

For more data on advertised products, use cards, last page.

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with steel fabrication to their individual needs!

Stainless steel tower test furnace rig. Suitable for high temperature and highly corrosive gases

FOR QUALITY CONTROL

Magnetic particle inspection
Mass spectrometer testing
X-ray inspections
Penetrant dye checking

See Sweet's Catalog File and Chemical Engineering Catalog

Call or write for a consultation with a trained Koven representative and send for bulletin #550

SPECIALISTS IN INTRICATE FABRICATION USING:

STAINLESS STEEL • ALUMINUM • MONEL • NICKEL • INCONEL • ALL CLAD MATERIALS • NICKEL PLATED STEEL

High pressure vessels; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; Fabrication to all A. S. M. E. Codes.

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FOR 80 YEARS KNOW-HOW AND QUALITY CONTROL HAS BEEN A KOVEN TRADITION

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Suppliers . . .

Brooks' sales in electronic instrumentation. The firm will operate as a subsidiary of Brooks under the name of Hydropoise, Inc.

INFORMATION SYSTEMS, INC., has named **Henry L. Bechard** director of engineering, Systems Division. Bechard was formerly assistant to the general manager of T.R.W. Computers.

BURRELL CORP. has elected **Lloyd V. Guild** to the board of directors. Guild has been with the firm since 1941 as research director and was elected vice president in charge of research and product development in 1955.

T. D. WILLIAMSON, INC., has appointed **Donald R. Westbo** factory sales engineer in the Gulf Coast area. Before joining T. D. Williamson, Westbo was a sales engineer for Holcomb Co., Inc., Shreveport, La. He will headquarter at Williamson's Houston branch office.

F & M SCIENTIFIC CORP. has promoted **Michael G. Beck** from district sales manager in the middle Atlantic area to company sales manager. He will direct F & M's over-all sales activities in the U.S. and abroad.

BOSTON WOVEN HOSE & RUBBER DIVISION, American Biltrite Rubber Co., has appointed **Donald M. Mahady** belting product manager. Mahady has been with the division for the past two years as district manager, New York City.

PENNSALT CHEMICALS CORP. has elected **James McWhirter** a vice president. McWhirter, general manager of Industrial Chemicals Division, has been with Pennsalt since 1945.

U.S. INDUSTRIES, INC., has appointed **John Laspia, Jr.,** manager of its Washington office. Laspia joined the company in 1959 as Washington representative.

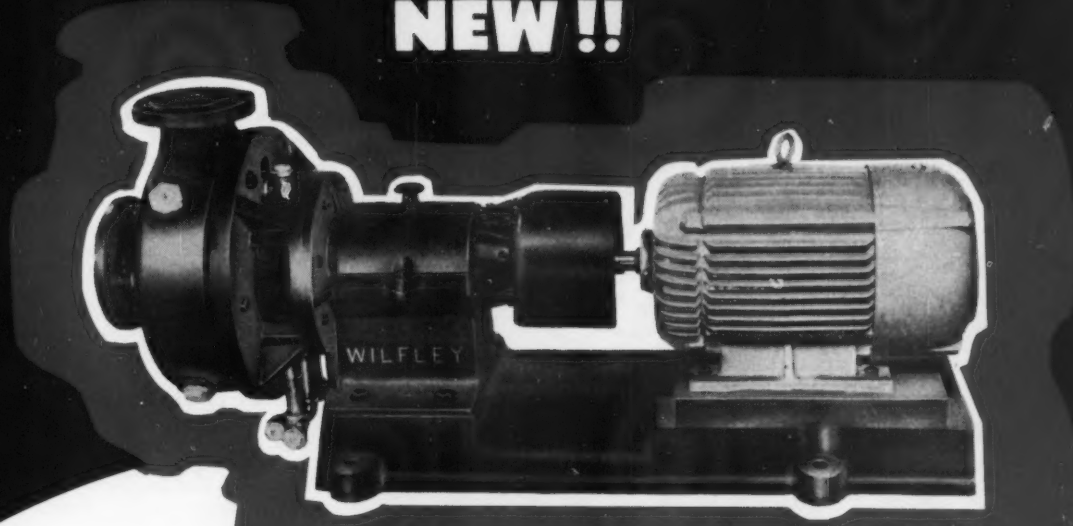
PARKER SEAL CO. has named **Pierce R. Tower** sales representative for the northeast part of Los Angeles, San Gabriel Valley, and San Bernardino and Riverside counties, in Southern California. **Alfred Finch** has become representative for Parker Seal products in the Washington and Oregon areas.

GRISCOM-RUSSELL CO. has elected **Robert Logie,** vice president and general manager, to the additional post of treasurer. Logie has been with Griscom-Russell since January 1960.

CRUCIBLE STEEL CO. OF AMERICA has appointed **Stephen A. Fronek** product sales manager of silicon steels. Fronek joined Crucible in 1925 as a metallurgist in Pittsburgh.

GULTON INDUSTRIES, INC., has bought West Instrument Corp., Chicago, makers

NEW !!



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STEAM JACKETED ACID PUMP

For Solutions Which Freeze Above Ambient Temperatures.

Wilfley's new, completely steam jacketed acid pump guarantees trouble-free, low cost pumping of solutions which thicken or solidify above ambient temperatures, such as ammonium nitrate, liquid sulfur, asphalt, etc.

Multiple steam line connections are provided on the case, case plate and stationary seal ring housing. In use, any two connections on each jacketed part are connected to the incoming and return steam lines. Steam connections are tapped for ¾" pipe. Any frame size #2 Wilfley Acid Pump can be converted to a steam jacketed assembly.

Every Installation Is Job Engineered.

Wilfley Sand Pumps
"Companions in Economical Operation"
Wilfley Acid Pumps

Write, wire or phone for full details.

A. R. WILFLEY and SONS, INC.

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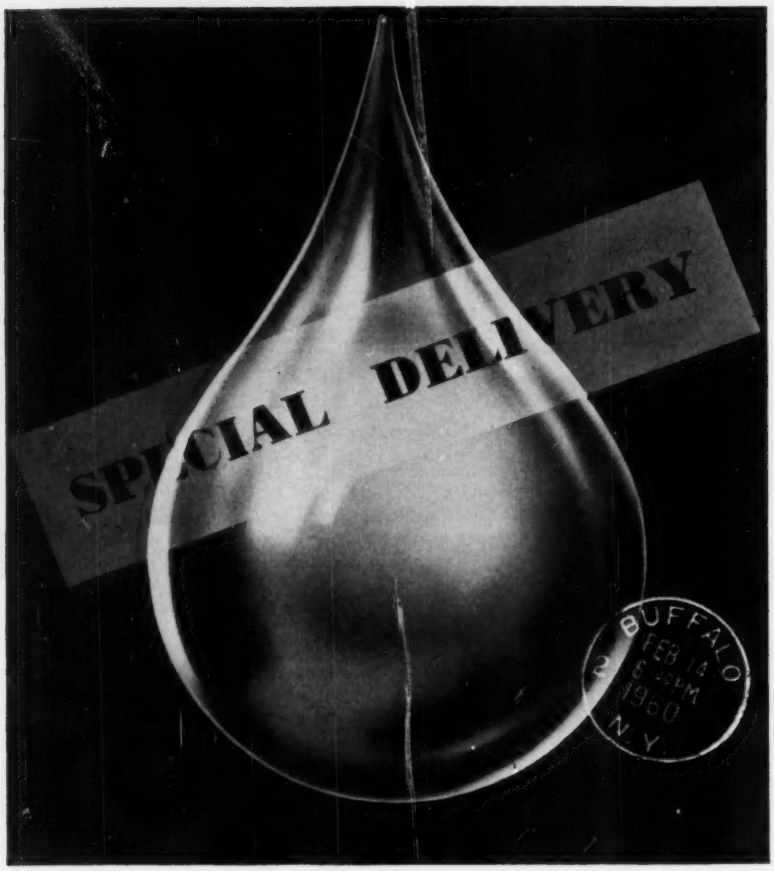
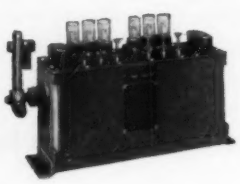


deliver a drop of oil?

Whether you're operating high-compression diesels or fast-moving shear knives, you're probably paying more and more attention to lubrication *timing*. Whatever your field, our engineers will be glad to study your requirements and make specific recommendations. Your needs can be met either by adapting an existing model — or we will custom-build you your own lubricating system. Write for our catalog. Manzel, 256 Babcock Street, Buffalo 10, New York. You will get exact, on-time lubrication if you



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A UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

Suppliers . . .

of precision temperature control equipment. Gulton, headquartered in Metuchen, N.J., specializes in materials research, electronics, components and systems engineering.

UNION CARBIDE CHEMICALS CO. has promoted **Eugene T. Clayton** to project leader at its Tarrytown, N.Y., technical service laboratory. He will work in marketing research.

UNION PUMP CO. has named **A. G. McDonough** product manager, centrifugal pumps. McDonough joined the firm's sales staff as centrifugal pump application engineer in February this year. He was formerly with Wilson-Snyder pumps.

PEABODY ENGINEERING CO. has made **Robert Kopita** general sales manager. Kopita joined Peabody in 1941 in the Gas Scrubber Division. He became manager of the division in 1948 and assistant general sales manager in 1959.

LANG WAYNE EQUIPMENT CO., Salt Lake City, Utah, has elected **Stanley M. Wells** president. Wells joined Lang Wayne in 1940 and has been in various sales positions.

NATIONAL LEAD CO. has elected **Thomas F. Owens** treasurer, replacing **Joseph J. Morsman, Jr.,** who has retired. Owens has been assistant comptroller of National Lead since 1951.

JEFFERSON CHEMICAL CO., INC., has assigned **Bruce W. Tyler** as salesman in its New York regional sales office. Tyler came to Jefferson from Dill Co., where he had been assistant to the vice president.

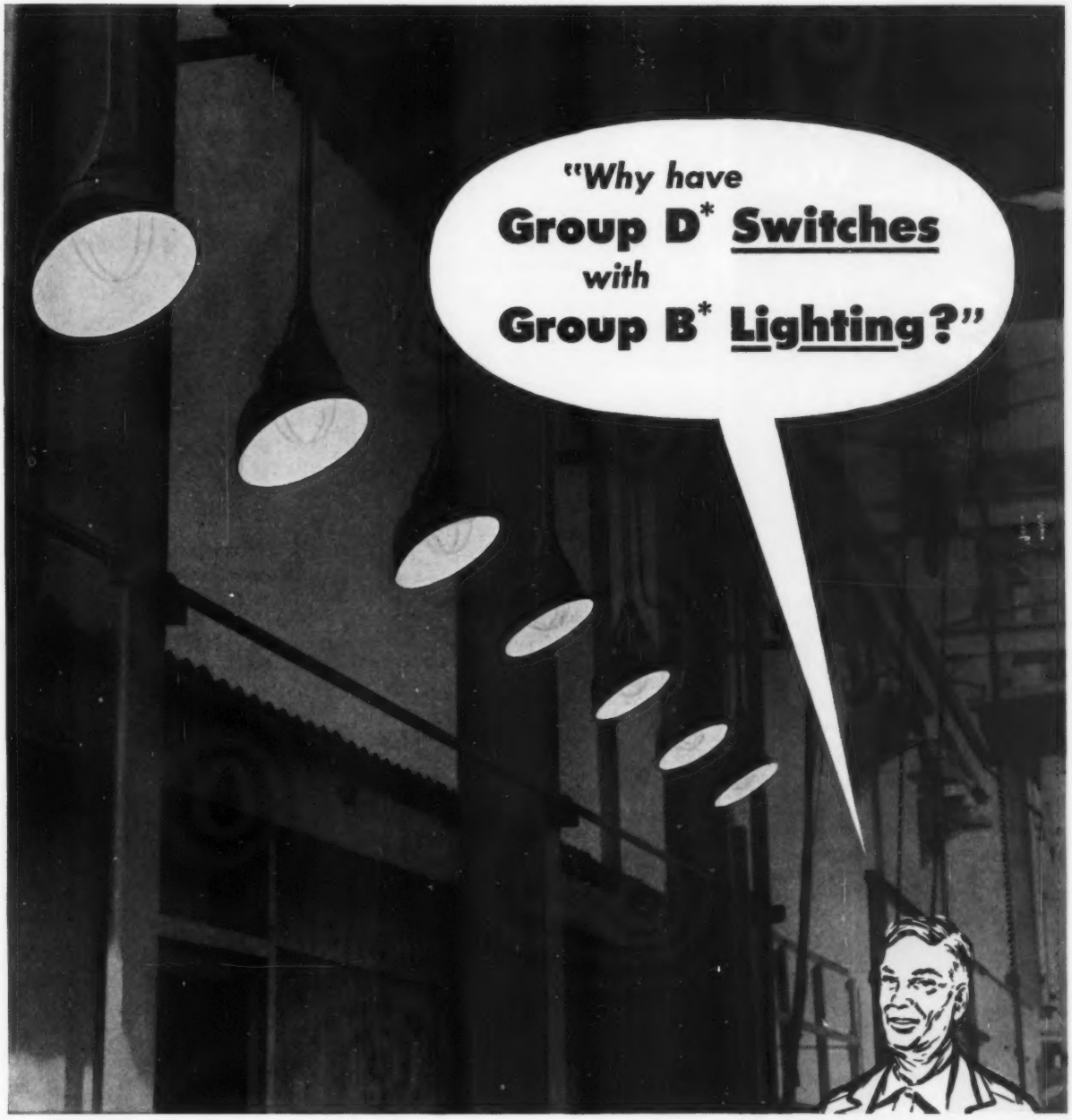
OHIO INJECTOR CO. has elected **William H. Fellows** vice president, marketing. Fellows joined Ohio Injector, a manufacturer of industrial valves, in December 1957 as national sales manager.

BORG-WARNER CORP.'s Reflectal Corp. has appointed **Gilbert L. Smith** general sales manager. Smith comes to Reflectal from Kaiser Aluminum & Chemical Sales, Inc., where he was manager of industrial building products.

ALCO PRODUCTS, INC., has elected **William G. Miller** executive vice president. A director of the firm since 1959, Miller had been vice president in charge of thermal and petroleum industry equipment groups since 1960.

DORR-OLIVER, INC., has named **Glenn O. Wilson** manager of sales technical divisions, International Division. Previously director of technical coordination, Wilson joined Dorr-Oliver in 1928.

HAYNES STELLITE CO., division of Union Carbide Corp., has appointed **Glen H. Shelton** works manager. Shelton, for-



Why, indeed? As long as you're in a hydrogen area, there's just as much danger of explosion with one piece of equipment as there is with the other.

And the same goes for acetylene areas, too. *And* for all other pieces of electrical equipment in such an area . . . fixture hangers, seals, flexible couplings, junctions, push button stations.

Crouse-Hinds is the only single source for complete systems of UL-listed explosion-proof electrical equipment, no matter what the National Electrical Code Class or Group.

Crouse-Hinds is also your prime source for expert assistance in choosing and applying equipment for hazardous areas. A Crouse-Hinds Field Engineer is always available to help you plan complete protection in flammable atmospheres of gases, vapors or dusts.

Call your Crouse-Hinds Distributor while you're still in the planning stage of building or remodeling. *That's* the time he can really save you money!

**National Electrical Code designations*

CROUSE HINDS

REG. U.S. PAT. OFF

MAIN OFFICE: SYRACUSE, N.Y. FIELD OFFICES: Albany, Atlanta, Baton Rouge, Birmingham, Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Corpus Christi, Dallas, Denver, Detroit, Houston, Indianapolis, Kansas City, Los Angeles, Milwaukee, New Orleans, New York, Omaha, Philadelphia, Pittsburgh, Portland, Oregon, St. Louis, St. Paul, Salt Lake City, San Francisco, Seattle, Tampa, Tulsa, Washington. **RESIDENT REPRESENTATIVES:** Baltimore, Md., Meriden, Conn., Reading, Pa., Richmond, Va., Springfield, Mass. **Crouse-Hinds of Canada, Ltd., Scarborough, Ont. Crouse-Hinds-Domex, S.A. de C.V. Mexico City, D.F. Peterco, Sao Paulo, Brazil**

Suddenly you "Had it Made"

because you "HOLED" the MOST UNUSUAL Christmas gift-giving idea for *customers, employees and friends* EVER SEEN!

★ ★ ★ ★

Yes, you were "*really in action.*" Your customers even called to say "THANK YOU" for your *unique and wonderful remembrance* and thereby opened the door to ADDITIONAL SALES! Your employees and friends too, *showed their appreciation* in the many small ways ONLY YOU would understand.

★ ★ ★ ★

If you buy gifts *(between $7.50 and $100.00 each)*, you'll surely want to see this *unusually practical, sensationally simple* and *refreshingly different* way of saying "THANK YOU" to the people who are IMPORTANT TO YOU AND YOUR COMPANY.

WRITE FOR MORE INFORMATION... MAIL THIS COUPON TODAY

Automated Gift Plan, Inc.
80 Park Avenue, New York 16, N. Y.
PR-5A

Please send further information

Company _____

Address _____

City _____ Zone ___ State _____

Att. _____ Title _____

We use approx. _____ Gifts in the $7.50 to $100.00 price range

Suppliers . . .

merly assistant works manager, succeeds **F. C. Kroft,** who has been named staff assistant to the company's president.

BORG & BECK DIVISION, Borg-Warner Corp., has elected **A. A. Krueger** vice president of sales and **R. L. Smirl** vice president of engineering. Krueger, who has been with Borg & Beck for 40 years, was formerly sales manager and assistant to the general manager. Smirl has been with the division for 25 years, beginning as a project engineer.

HARSCO CORP. has elected **H. E. Cragin, Jr.,** vice president, foundry sales. Cragin, who will headquarter at High Bridge, N.J., has been factory superintendent, plant manager and general sales manager with the company.

DORR-OLIVER, INC., has transferred **Harry Harrison** from the Engineering Department to the Pump Sales Division as application engineer. Harrison joined Oliver United Filters, Inc., a Dorr-Oliver predecessor, in 1943, and has been a specialist in pump engineering.

LONE STAR STEEL CO. has promoted **J. M. Hollingsworth** manager of cast iron pressure pipe sales since 1957, to manager, Spiral Weld Pipe Sales Department. Hollingsworth joined Lone Star in 1950.

HARRIS CALORIFIC CO., manufacturer of gas welding and cutting apparatus and laboratory gas regulation equipment, has appointed three men to its engineering staff: **Frank Hach, Jr.,** chief industrial engineer; **Alfred E. Burnell** and **Joseph J. Okladek,** product engineers.

PETROLITE CORP. has named **R. Murph Jones** marketing director. Prior to joining Petrolite, Jones was with the nuclear branch of Lockheed Aircraft Corp.'s Georgia Division.

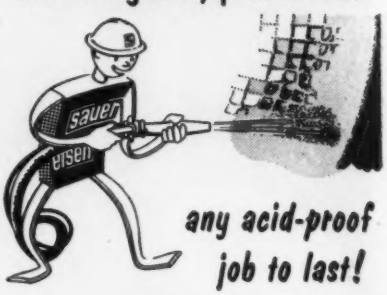
U.S. STEEL CO.'s Oil Well Supply Division has named **Grant A. Jackson** manager, tubular sales, mid-continent area. Jackson will make his headquarters in Tulsa, Okla.

WORTHINGTON CORP. has appointed **Robert F. Hoffman** general superintendent, Harrison Division. Hoffman joined Worthington in 1946 as research engineer at the Harrison Division and has been assistant manager of foundries since 1956.

AIRESEARCH MANUFACTURING CO. OF ARIZONA has appointed **Robert A. Fletcher** sales manager, industrial gas turbines. Fletcher joined Airesearch in 1959 after being sales manager of Solar Aircraft Co.

BORG-WARNER CORP. has elected **E. S. Russey** chairman of Borg-Warner, Ltd.,

You can gunite, pour or cast



any acid-proof job to last!

Yes, Sauereisen Pour-Lay Cement No. 54, the **Acid-Proof Concrete,** is ready to go to work for you, too . . . for floors, tanks, chimneys. Provides resistance to all corrosive acids (except hydrofluoric) and temperatures as high as 2000°F. Can be gunited, poured, cast in forms or applied as a topping over concrete, brick or tile.

Ask for Data Sheets.

Sauereisen Cements Co.
Pittsburgh 15, Pa.

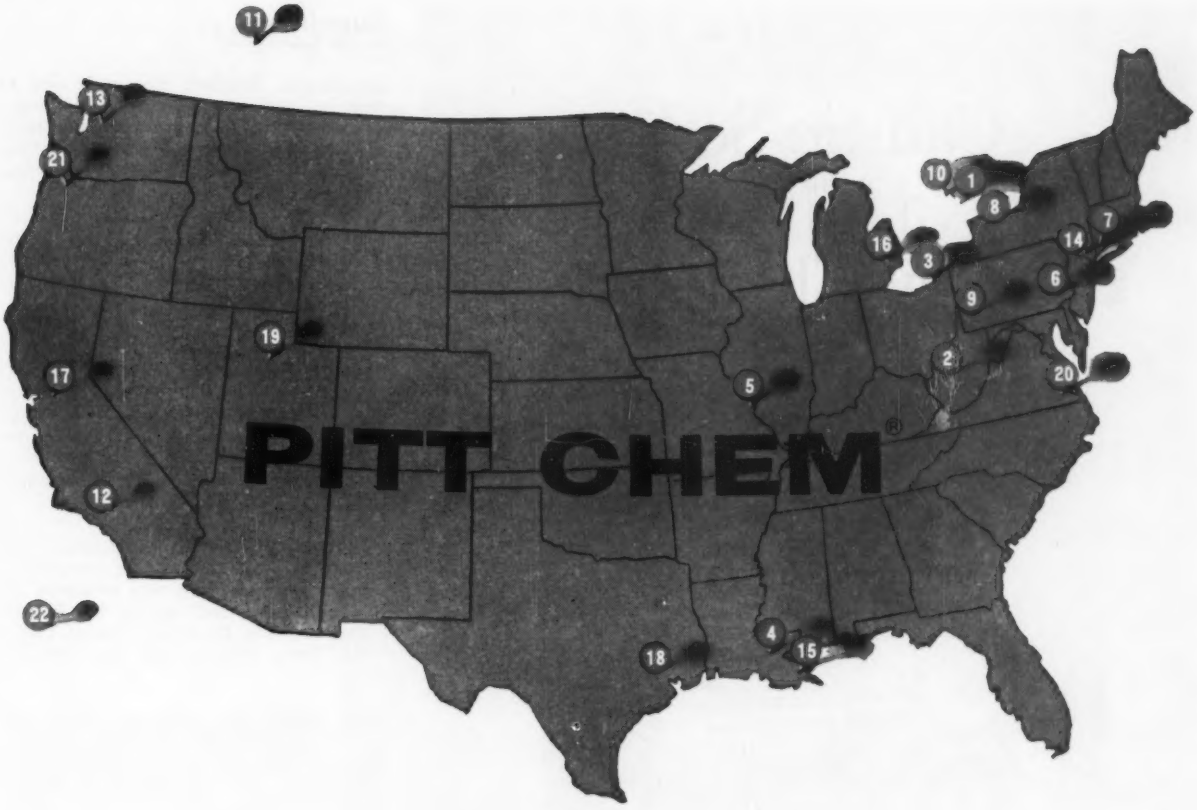
SAUEREISEN POUR-LAY CEMENT No. 54
PAT. APPLIED FOR

Storage Tank Vent Drier GUARDS Liquids against Moisture . .

This 40" desiccant-type drying column will protect tanks from 500 gallons to 50,000 gallons. The unit will dry vent air to a dew point of minus 100°F.

Write for Complete Details

W. A. Hammond Drierite Co.
120 Dayton Avenue, Xenia, Ohio



A Proven Way to Map an Efficient, Cost-Saving Corrosion Prevention Program

PITT CHEM INDUSTRIAL COATINGS

Distributors & Agents

1. **Allied Basic Chemical Co., Ltd.**
35 Anderson Avenue
Toronto 12, Ontario, Canada

2. **Allied Services, Inc.**
160 Spring Street
Charleston, W. Va.

3. **Bodwell-Lemmon Company**
10701 Broadway
Cleveland 25, Ohio

4. **Construction Materials, Inc.**
474 North Foster Drive
Baton Rouge, Louisiana

5. **Corrosion Products, Inc.**
5627 Manchester Ave. (Box 6065)
St. Louis 10, Missouri

6. **East Coast Distributors, Inc.**
1518 Brandywine Street
Philadelphia 30, Pa.

7. **The Esbec Corporation**
190 Henry Street
Stamford, Connecticut

8. **John J. Gerdon**
220 Broadway
Buffalo 4, New York

9. **G. V. Hamilton**
326 Linden Avenue
McKees Rocks, Pa.

10. **Insul-Mastic Eastern, Ltd.**
1454 Bloor Street, West
Toronto 9, Ontario, Canada

11. **Magnachem, Ltd.**
5507 First Street, S.E.
Calgary, Alberta, Canada

12. **Magna Products, Inc.**
11808 South Bloomfield Ave.
Santa Fe Springs, Calif.

13. **Marine & Industrial Supply Co.**
1123 West Hanford Street
Seattle 4, Washington

14. **John E. Nicholson Co., Inc.**
426 East 110th Street
New York 29, New York

15. **Pat O'Neal Enterprises**
P. O. Box 164
Harvey, Louisiana

16. **W. C. Peters Company**
11111 Sturgis Street
Detroit 34, Michigan

17. **T. H. Pitt Company**
1133 Mariposa Street
San Francisco 7, Calif.

18. **Stockdale, Inc.**
P. O. Box 19085
Houston 24, Texas

19. **Robert Taylor & Sons**
P. O. Box 1223
Salt Lake City 10, Utah

20. **C. E. Thurston & Sons, Inc.**
850 Tidewater Drive
Norfolk, Virginia

21. **Waterworks Supplies Company**
4455 South East 24th Street
Portland 14, Oregon

22. **Gasgro, Ltd.**
P. O. Box 2454
Honolulu 4, Hawaii

A solution to *your* toughest corrosion problem is as "handy" as your nearest Pitt Chem Industrial Coating Distributor. These specialists in corrosion prevention are located strategically throughout the United States.

Whether you are interested in developing a complete, preventive maintenance program for your plant facilities, or are stymied with a specific corrosion problem, your Pitt Chem Distributor is geared to offer you complete assistance. His experience in solving a broad range of corrosion problems enables him to recommend the most effective and economical Pitt Chem protective coating program for you.

Call your Pitt Chem Distributor, he's listed in the Yellow Pages . . . get complete information on durable, economical Pitt Chem Coating Systems. 3306

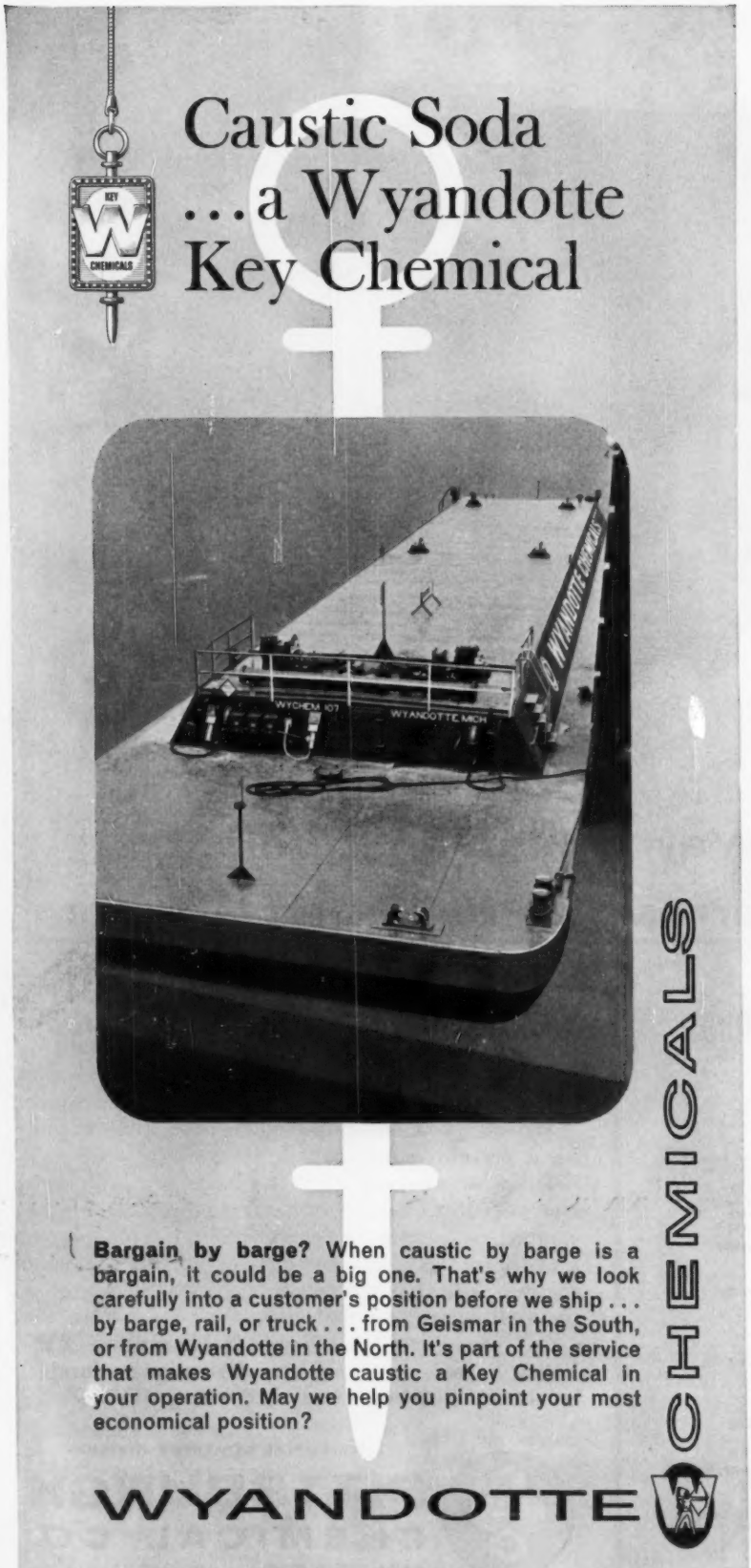
PROTECTIVE COATINGS DIVISION

PITTSBURGH CHEMICAL CO.

GRANT BUILDING PITTSBURGH 19, PA.

A Subsidiary of PITTSBURGH COKE & CHEMICAL CO.

For more data on advertised products, use cards, last page.


Caustic Soda
...a Wyandotte
Key Chemical
KEY
CHEMICALS
WYCHEM 107
WYANDOTTE, MICH
WYANDOTTE CHEMICALS
Bargain by barge? When caustic by barge is a bargain, it could be a big one. That's why we look carefully into a customer's position before we ship . . . by barge, rail, or truck . . . from Geismar in the South, or from Wyandotte in the North. It's part of the service that makes Wyandotte caustic a Key Chemical in your operation. May we help you pinpoint your most economical position?
WYANDOTTE CHEMICALS
MICHIGAN ALKALI DIVISION, WYANDOTTE, MICHIGAN

Suppliers . . .

Letchworth, England. Russey is also a director and vice president of Borg-Warner, president and general manager of both the Warner Gear Division, Muncie, Ind., and Warner Gear Co., Ltd., Windsor, Ont.

WORTHINGTON CORP. has named **William T. Walker** product engineer, reciprocating products section. Walker, who will headquarter at Decatur, Ala., is with Worthington's Air Conditioning Division.

KRUEGER ENGINEERING & MANUFACTURING CO., fabricators of heat transfer equipment for the hydrocarbon processing industry, has completed additions to its Houston plant. The project, which more than doubles the company's fabricating space, cost over $50,000.

PETROLITE CORP., Petreco Division, has elected **W. K. Mellon** vice president. Mellon, who has been vice president in charge of sales and service for Petrolite's Petroleum Rectifying Co. of California since 1937, joined the firm in 1919.

KELITE CORP. has appointed **Robert J. Racine** national sales manager. Racine came to Kelite as western regional sales manager in 1956. He will be in charge of all U.S. sales.

UNION PUMP CO. has elected **Thomas E. Hall** vice president of engineering. Before joining Union Pump in 1959, Hall was administrative engineer for Byron Jackson Pump Division, Borg-Warner Corp., Los Angeles.

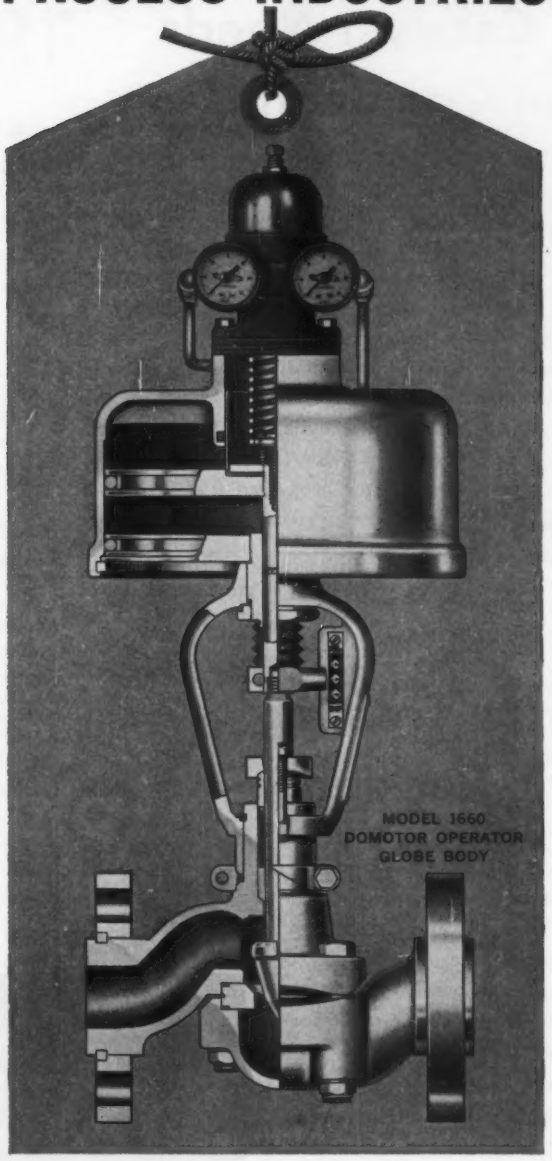
FOXBORO CO. has named **Howard R. Cushman** regional sales manager, New York territory. He succeeds **John E. Hewson,** who has been appointed field manager, Systems Engineering Division.

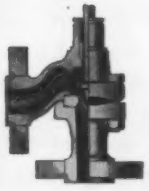
ACF INDUSTRIES, INC., has elected **Lawrence Wilkinson** a director. Wilkinson is executive vice president of Continental Can Co., having joined that company in 1951.

Use Readers' Service Postcard, Page 447 for more information on advertised products.

WHY ANNIN IS A LEADING SUPPLIER OF CONTROL VALVES TO THE PROCESS INDUSTRIES

Annin control valves have been designed with the needs of the process industries in mind. The split body, single seat construction reduces body turbulence and erosion, gives longer life. The interchangeability of Annin valve components, the easily replaceable trim, the option of angle or 3-way bodies carried in stock for immediate shipment, simplifies your installation and maintenance problems. The flexibility in basic design cuts down on the valve parts inventory ordinarily required for a variety of plant applications. Another factor is the $1½ million in alloy body parts regularly carried in Annin stock, including a wide range of 300 series stainless steels, Hastelloys, Monel, Inconel, Durimet-20, and a variety of bronzes. If reduced valve inventory, design flexibility, and economical maintenance are factors in your operation, we suggest you investigate the advantages inherent in Annin process control valves.



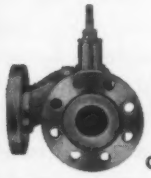


ANGLE BODY

For fluid problems involving solids in suspension, high viscosity fluids, and applications requiring special nozzle materials or design.

3-WAY BODY

Provides two horizontal line connections and an individual bottom vertical line connection. Sections may be rotated for convenience.



CORNER BODY

Standard for body sizes ½"–2". Often used to replace expensive alloy ells, this body simplifies installation and conversion on the job.

ANNIN DESIGN FLEXIBILITY reduces inventory...simplifies installation and maintenance...as no other control valve can!

Send today for General Catalog 1500-E

ANNIN VALVES

Products that work for your profit.

THE ANNIN COMPANY
1040 S. Vail Avenue • Montebello, California

For more data on advertised products, use cards, last page.

New Equipment & Literature...

as selected by Frank L. Evans, Jr., Mechanical Engineering Editor

Reforming Catalyst Needs No Halogen Compounds

In catalytic reforming with platinum catalyst, it has been assumed that halogen, such as chlorine, was a necessary component of the catalyst system.

However, commercial reforming operations using a new halide-free catalyst have fully demonstrated that halogen is not required for successful catalytic reforming operations.

This catalyst is now being used in Houdriforming units in Japan. It is producing high yields of motor gasoline of the desired high octane number, at relatively mild operating conditions and without addition of halogen compounds to the feed. In addition, hydrogen purity, a measure of reforming selectivity is also at a high level.

The new catalyst contains the same amount of platinum as other Houdriforming catalysts. It is readily regenerated in place for restoration of activity after prolonged use. Technical details are available. Houdry Process Corp.

Circle E1 on green card, last page

64-Page Manual Details Control Valve Section

"Control Valves" is the subject of a new 64-page comprehensive manual fully describing pneumatic diaphragm and piston actuators, and a wide variety of valve body assemblies. A 20-page specifying section contains the information necessary for selection of a control valve. Accessories, such as valve positioners, handwheels, electropneumatic transducers, etc., are also included. The manual includes a discussion of valve body and trim materials, a description of various styles of valve plugs, pressure-temperature ratings, maximum pressure drop tables, and performance data including frequency response. Completely illustrated and easy to read with many tabulations and listings. Fisher Governor Co.

Circle E3 on green card, last page

Better Waste Treating With Plastic Packing

A new plastic packing for efficient and economical treatment of water-borne wastes in trickling filters called Dowpac 20A, consists basically of individual sheets, corrugated in two directions, measuring approximately 36 x 21 inches. A unique, self-spacing design permits the sheets to be assembled side by side to form a cubic module for erecting an aerating tower of appropriate size.

Industrial wastes processed through a structure using Dowpac demonstrate sufficient purity for recirculation through plant processing operations or for discharge into storm sewers, lakes or streams. The structure itself is much more compact and efficient than trickling filters utilizing rock, blast furnace slag or similar packing media.

Pilot plant installations have proved the effectiveness of both material and sheet configuration for treatment of domestic sewage and of water-borne wastes from general organic chemical manufacturing plants and phenolic petroleum refineries. Dow Industrial Service Div., The Dow Chemical Co.

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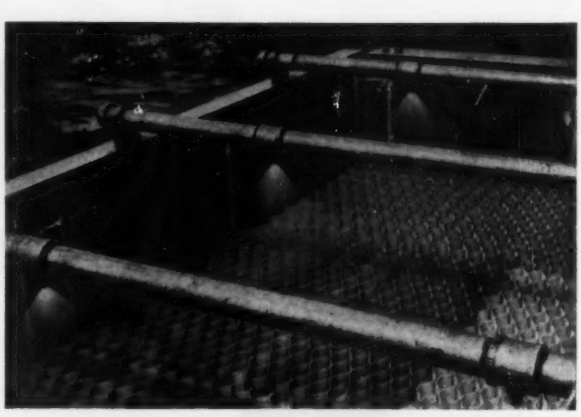


Corrugated plastic packing treats water-borne wastes.

REPUBLIC
OFFERS

TYPES **MORE**
TEMPERATURE RANGE
PORTINGS
SHAPES
PLUG DRILLINGS
MATERIALS
SERVICES
SIZES
IN

PLUG VALVES

Brass, aluminum alloy, or stainless steel bodies, flanged or unflanged, with TEFLON (no lubricant), brass, or stainless steel plugs! Flared tube, internal or external pipe port connections! ⅛" to 1". 2 to 5 ports! Six metal-plug lubricants for many services—air, vacuum, water; gaseous oxygen; alcohol; gasoline and high octane fuels; hydrocarbons and hydraulic oils; acids and alkalis; and food. When you need plug valves, investigate Republic's broad line of standard types!!!

And special-purpose valves, too! There is one designed especially for drawing off accurate, minute samples for GAS CHROMATOGRAPHY analysis! Another, 3" and 4" SLURRY valves with rubber-covered rising plug for long service life! And a CYLINDRICAL plug type that features low pressure drop and easy turning.

Yes, Republic offers **more** in plug valves! What do **you** need?

Stocking distributors coast to coast 334

REPUBLIC RM
FLOW • DIRECTIONAL • PRESSURE CONTROL
VALVES

15655 Brookpark Road, Cleveland 35, Ohio

Work Gets Done Faster with a
RIDGID®
TRISTAND VISE
on the job!

Here's a solid workbench to speed all cutting, threading and reaming out on the job. No other vise offers as many work-saving features as this RIDGID No. 40-A Tristand Yoke Vise. • Big, rugged malleable vise base has 3 bending grooves, 6 tool slots, rear pipe rest and a ceiling brace screw for absolute rigidity if legs aren't bolted down. • Base overhangs front legs for clear tool swing. • Extra-large yoke latch opens for easy, fast insertion of long pipe lengths. • Replaceable LonGrip jaws give, slip-proof grip. • Handy tool tray locks legs open during use but folds for easy carrying with legs snap-chained together. RIDGID No. 450 Tristand Chain Vise with ⅛" to 5" capacity is also available.

EASY TO FOLD

EASY TO CARRY

Extra Rigid in Use

Call your Distributor today. For your convenience, he maintains a complete stock of RIDGID Work-Saver Pipe Tools and parts.

RIDGID
The Ridge Tool Company • Elyria, Ohio, U.S.A.

For more data on advertised products, use cards, last page.

New Equipment . . .

Gasoline Sweetening Described in Brochure

Inhibitor sweetening of gasoline stocks with Tenamene 2, a phenylenediamine-type antioxidant, is described in detail in a new brochure which outlines the various methods used in gasoline sweetening operations. Also included is a description of the materials used and the reaction mechanism which is thought to occur in the inhibitor sweetening process. Equipment requirements and a flow diagram are also presented.

Another section of the brochure discusses the variables that affect inhibitor sweetening, factors such as temperature, antioxidant concentration, oxygen content of the hydrocarbon, and caustic requirements. The technical data concludes with a simplified method of determining the response of gasoline stocks to this sweetening method. Eastman Chemical Products, Inc.

Circle E4 on green card, last page

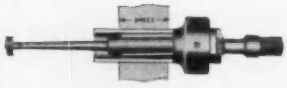
WIEDEKE

THE QUALITY NAME IN TUBE EXPANDERS . . . SINCE 1892

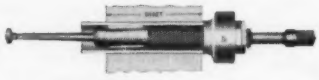
Tube Expanders for Condensers

No. 255—for average tube sheets

No. 270—for thick or multiple tube sheets



No. 255—Adjustable for sheets up to 2¼" thick



No. 270—Adjustable for sheets up to 7½"

#36

IDEAL

IDEAL Ball Bearing Tube Expanders are made of special analysis alloy tool steels, carefully heat-treated to withstand the severest operating strains. They are adaptable for use with any torque controlled tube rolling units—air, electric or mechanical. *Confidence* is your assurance that your job will be done *RIGHT* . . . when you use WIEDEKE Specialized Tube Expanders, Tube Cutters and Operating Accessories. There is a Wiedeke Distributor in every principal city. For further information write for new General Catalog 81.

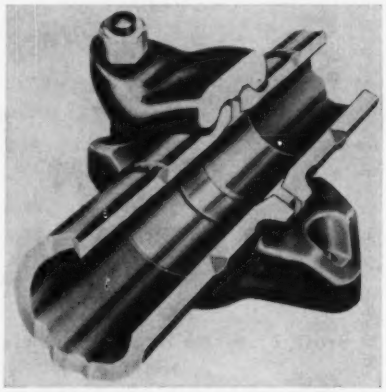
The Gustav WIEDEKE Company

Dayton 1, Ohio

Pipe Connections Pass Extensive Pressure Tests

Grayloc pipe connections employ a completely new principle in sealing liquids and gases under high pressure. They show equal or better resistance than other types of connections to internal or external pressure, bending, tension, compression, torsion or a combination of such forces.

In pre-marketing tests, a 2-inch connection withstood 26,000 psi at which point the pipe failed. A 7-inch



Grayloc withstood 19,500 psi. In a test conducted by a government agency, a 10¾-inch-OD Grayloc held under a bending moment of 2 million pound feet.

Already in use in refineries and chemical process plants, the connections have been field proven under the most severe conditions. Applications in which they have been used include live steam, hydrogen, hot oil, reflux lines and concentrated acid transport systems.

Standard all-steel connections are stocked in sizes from 1 inch to 30 inches, however special sizes and special alloys are available on request. Collar-type connections, in addition to the regular-clamp type, are also available.

Complete copies of the test reports on Grayloc connections and case histories are available on request along with price information and the Grayloc catalog. Gray Tool Co.

Circle E5 on green card, last page

Indicator Has Scales on Spools for Easy Changes

Changing scales to suit changing process requirements is simplified in a unique pneumatic receiver known as Selecto-Scale. The new receiver provides a multiple of scales in one instrument. Scales are printed on tough laminated, "dead stretch" mylar

Photographed at DX Sunray, (Tulsa Refinery)

For higher yield...new Aerocat 3C

CAN YOU USE a higher yield of gasoline—? or of propylenes or butylenes—? Then investigate the new AEROCAT 3C! It's a new fluid cracking catalyst composition, developed by Cyanamid in cooperation with a major oil company. AEROCAT 3C-12 gives increased gasoline yield . . . AEROCAT 3C-20, increased propylene and butylene yields . . . both at the expense of dry gas and coke.

In actual commercial operations, these new three-component catalysts have proved their ability to provide refiners with more flexible, more profitable operation. They are highly active, exceedingly stable, and completely operative.

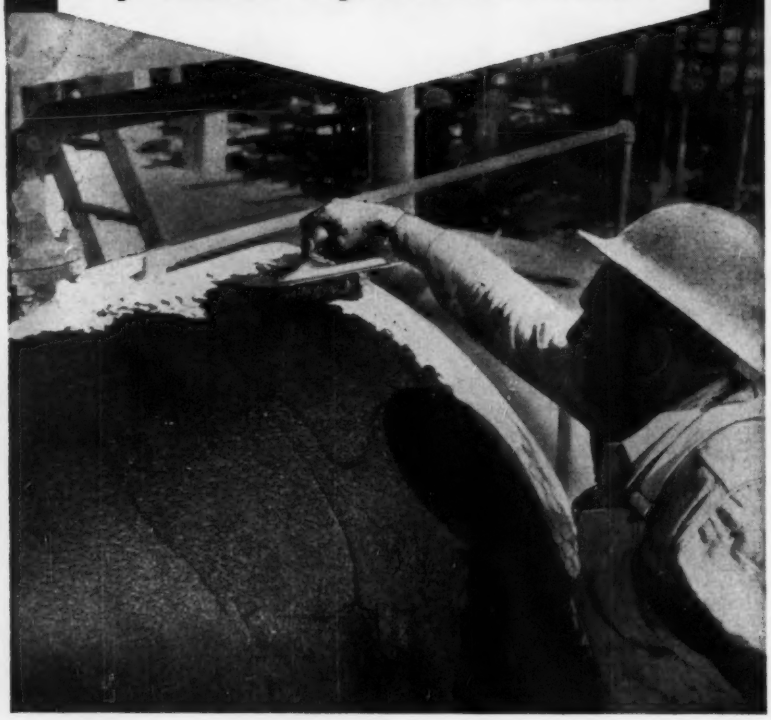
Your "Man with the Golden Rule"—your Cyanamid salesman—will be glad to work with you to determine the suitability of AEROCAT 3C for your needs. He knows catalysts—and behind him are the resources of a major producer of both catalysts and other chemicals. Why not call him now?

Basic in catalyst chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, New York 20, New York

Laykold® WEATHERCOAT
protects exposed insulation



INSULATION on towers, tanks and exchangers must be kept DRY. If moisture gets through, the efficiency drops.

Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single*, thick layer.

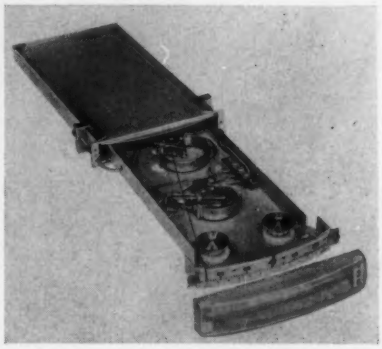
Write today for our free illustrated brochure, entitled "Laykold Weathercoat for Insulation Protection."

American Bitumuls & Asphalt Company

320 MARKET, SAN FRANCISCO 20, CALIF.
Perth Amboy, N. J.
Baltimore 3, Md.
Cincinnati 38, Ohio
Atlanta 8, Ga.
Mobile, Ala.
St. Louis 17, Mo.
Tucson, Ariz.
Portland 8, Ore.
Oakland 1, Calif.
Inglewood, Calif.
San Juan 23, P. R.

BITUMULS® Emulsified Asphalts • CHEVRON® Paving Asphalts • LAYKOLD® Asphalt Specialties • PETROLASTIC® Industrial Asphalts

New Equipment . . .



tape, stored on spools, ready for easy positioning on dial face when a change in process requires new scale values.

New scales are rotated into view through easily accessible adjustments. Width of each scale is 4½ inches. A red set hand is clipped onto the dial and aligned as required. Minor deviation of the indicating pointer from normal operating condition can be detected quickly from a distance, substantially reducing reading time and virtually eliminating reading errors.

Selecto-Scales are mounted in panel boards vertically or horizontally. Because of their slim design, five can be set in the same space required by four circular gauges of equivalent scale length. United States Gauge Div., American Machine & Metals, Inc.

Circle E6 on green card, last page

Mechanical Seal Developed For High Pressure Process

A new type of mechanical seal assembly designed to serve high pressure conditions has been developed to meet specific needs in the chemical, petrochemical and petroleum refining industries.

The Type HPTO high pressure dura seal is thoroughly field-tested and approved. Successful applications have been made on high pressure autoclaves, boiler feed pumps and high pressure refinery pumps handling liquefied petroleum gases.

The seal is a single, inside-balanced mechanical seal of ultra heavy duty construction. It utilizes a tung-car sealing member mated with Dura No. 5 carbon. The carbon face is designed with specially engineered slots to provide a sturdier bearing face.

A major reason for the successful operation of this seal lies in the highly efficient combination of face materials. Tung-car is superior to Stellite

What Really Happens Inside the Bucket

Exploding a widespread misconception of the operation of inverted bucket steam traps

In describing the operation of the inverted bucket trap many well meaning people—and some not so well meaning; i.e., competitors—refer to the need for a "bucket full of steam" to close the trap, and a "bucket full of condensate" to open the trap. The implications of these requirements are many. Sometimes they are contradictory. Often they are misleading. Observations of a trap with a glass body and a glass bucket plus trap design considerations tell the true story.

* * *

In a well designed inverted bucket trap (Armstrong, naturally) the bucket will float and close the valve when it is *no more than two-thirds full of steam.* For example, the bucket in an Armstrong No. 812 trap is $3^{15}/_{16}$" deep. It will float with only 2" of steam.

Good design also dictates that the maximum test opening pressure of a trap should be well in excess of the maximum working pressure for which the trap is furnished. For example a No. 812 trap for 100 psi with the bucket filled with cold water should open at a test pressure of at least 165 psi. Therefore, the bucket does not have to fill completely with condensate to open at 100 psi. The entrance of 1.20" of condensate will cause the bucket to sink. .8" of steam remains at the top of the bucket at the time it is heavy enough to open the valve at 100 psig and with no back pressure.

Thus the opening and closing of a 100 psi trap with $3^{15}/_{16}$" deep bucket is controlled by a change in the water level of only 1.20".

In actual practice the 100 psi trap may be draining a steam main in which daytime pressure is only 30 psig. Instead of requiring a 1.20" rise in bucket water level to open the trap against this pressure, the bucket will be heavy enough to open the valve as soon as the water level in the bucket has risen about $^3/_{16}$".

Obviously, it does not "take a bucket full of steam" to close the inverted bucket trap, or a "bucket full of condensate" to open the trap.

What's the Significance?

As illustrated above the opening of an Armstrong Trap requires the accumulation in the trap of less than one-third of a bucket full of condensate. This assures good operating characteristics for the vast majority of services by discharging small accumulations of condensate as soon as they reach the trap. It also assures frequent opening pressure drops to break up air and condensate films on heat transfer surfaces and thereby maintain high heat transfer rates in the unit being drained.

Additionally, the fact that no more than two-thirds of a bucket of steam is required to float the bucket means that there will always be a generous water seal at the bottom of the bucket. In the case of the No. 812 trap described above, it will be 1.8" deep. This insures that no steam can leak from the bottom of the bucket. More importantly, the bucket can float to close the valve even when the bucket is not completely submerged in condensate.

A Proven Principle Engineered Up to the Minute

While the inverted bucket concept for steam traps is half a century old, today's Armstrong inverted bucket traps incorporate design considerations unknown 50 years ago. The inverted bucket of the Armstrong trap, for example, is not just an upside down bucket. It is a carefully sized, weighted and vented component of a steam trap mechanism that experience proves will do its job right. Throughout, Armstrong design has kept pace with technological advancements, modified when necessary to meet changing requirements.

We do not claim that Armstrong Traps will do every single job better than any other trap. But we do believe it will do more jobs better and more consistently than any other trap. More important, though, for most services, Armstrong Inverted Bucket Steam Traps enable you to get more efficient steam utilization with minimum problems.

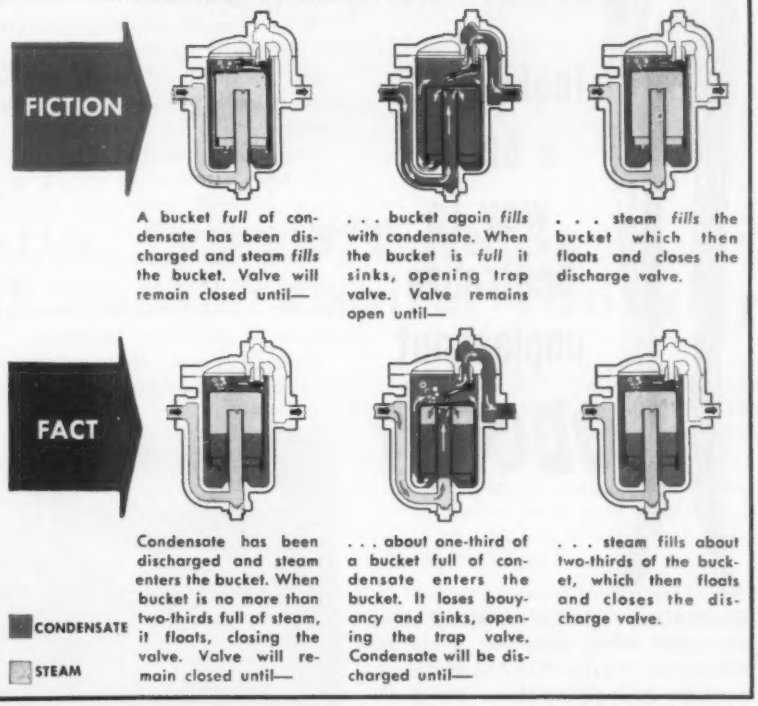
We're so sure of what Armstrong Traps can do that we unconditionally guarantee that they will satisfy you. You are the sole judge, too, so there's practically no risk.

* * *

The 48 page Armstrong Steam Trap Book describes other Armstrong features. It also discusses trap selection, installation and maintenance. Ask your Armstrong Representative for a copy or write: **Armstrong Machine Works, 8522 Maple Street, Three Rivers, Michigan.**

ARMSTRONG STEAM TRAPS

HOW THE INVERTED BUCKET TRAP WORKS


FICTION
A bucket full of condensate has been discharged and steam fills the bucket. Valve will remain closed until—
. . . bucket again fills with condensate. When the bucket is full it sinks, opening trap valve. Valve remains open until—
. . . steam fills the bucket which then floats and closes the discharge valve.
FACT
Condensate has been discharged and steam enters the bucket. When bucket is no more than two-thirds full of steam, it floats, closing the valve. Valve will remain closed until—
. . . about one-third of a bucket full of condensate enters the bucket. It loses bouyancy and sinks, opening the trap valve. Condensate will be discharged until—
. . . steam fills about two-thirds of the bucket, which then floats and closes the discharge valve.
CONDENSATE
STEAM

For more data on advertised products, use cards, last page.

looking for a better way to neutralize unpleasant ODORS?

Disguising, replacing or eliminating unwanted odors calls for a special knowledge of aromatics and ample experience in applying them in a given situation.

As basic producers, Penick has a comprehensive library of odorants, reodorants and deodorants for correcting a wide variety of undesirable odors, including "difficult" odors.

We would like to hear about *your* particular problem and to help find the solution for you. No obligation, of course. Why not use the coupon below?

PENICK *Aromatics and Flavors Department*

S. B. PENICK & COMPANY

100 CHURCH ST., NEW YORK 8
735 W. DIVISION ST., CHICAGO 10

Gentlemen: We would like your help.

Our odor problem is:_____

_____

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

New Equipment . . .

or Ceramic in that it will stand the additional loading required in handling the high pressures. Durametallic Corp.

Circle E7 on green card, last page

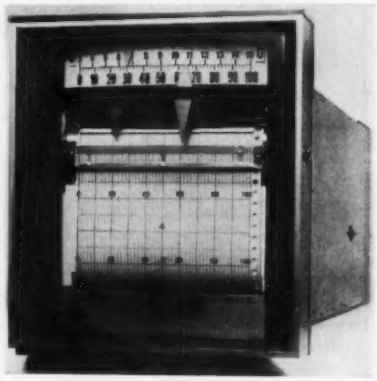
Now Auto-Manual Control With Pneumatic Instruments

A new line of miniature pneumatic instruments incorporates design concepts described as "vastly simplified start-up and operation" of industrial processes.

The line is called PneumatiK Tel-O-Set. It consists of 12 major types of 4-inch indicating, recording and controlling devices.

The new instrumentation makes possible manual-automatic control transfer without the complicated procedure of matching pressures.

Cascade control, the resetting of a set point of a primary controller by



a secondary controller, becomes practical and convenient for the operator for the first time.

Other advanced features provide for:

- Zero and damping adjustments to be made without removal of the recording chart drive mechanism.
- Continuation of process control on automatic or manual control when the recording or indicating chassis is removed.
- True reset bypass. On switching to manual control, valve loading pressure goes directly to the reset chamber and not through the reset needle valve. Thus, reset accumulation (windup) cannot occur.

The pneumatic instruments include one and two-pen strip chart recorders without and with control, single and two-station recording cascade control, one and two-point indicators with and without control, a proportional-plus reset controller and a proportional-plus, reset-plus rate controller. On the latter, rate control can be eliminated without removing or adding any parts.

All of the devices operate over the usual range of 3 to 15 psi and may be combined with any compatible transmitter and final control element. Pneumatic connections between a control station and a controller require only the tightening of a single screw.

Recorders and indicators have interchangeable cases sized to fit the 6 x 6-inch SAMA standard panel cutout. Chassis of both types of instruments also are interchangeable and have quick-connect air connections. Minneapolis-Honeywell Regulator Co.

Circle E8 on green card, last page

Booklet Covers Principles of Engineering Management

"Engineering-Management Status: Dream or Mirage?" is another in a series of "professional advancement" booklets written for the engineering profession. Qualities and skills required in successful management, but not necessarily essential to pure engineering are discussed along with rewards in the areas of engineering to be gained for developing further in the area of engineering or for moving into management status.

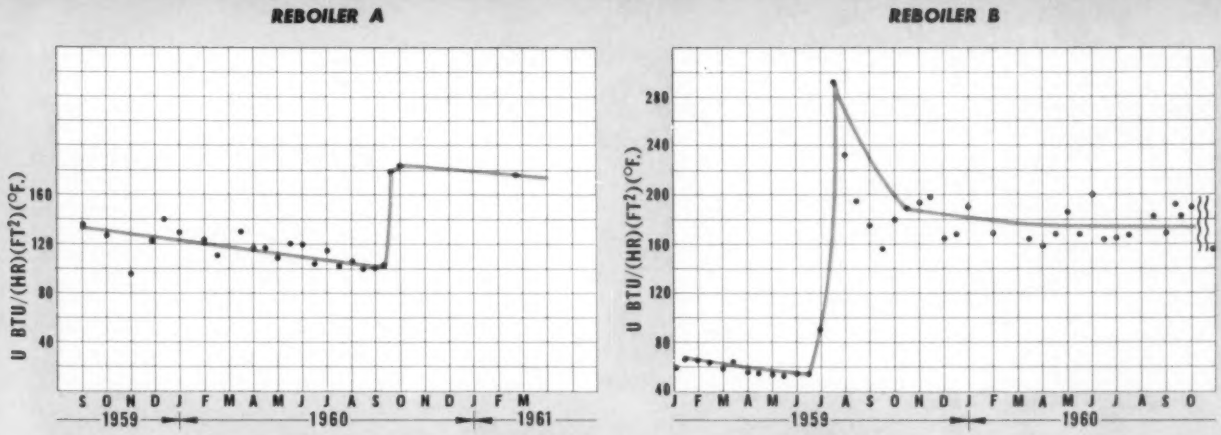
The message points out that some engineers are not psychologically inclined for management capacity, while others would find greater challenge and reward by developing management knowledge. It suggests self assessment before undertaking training for moving into management classification. Copies are available free of charge. Heat Exchanger Div., Western Supply Co.

Circle E9 on green card, last page

Air or Gas-Operated Portable Utility Pump

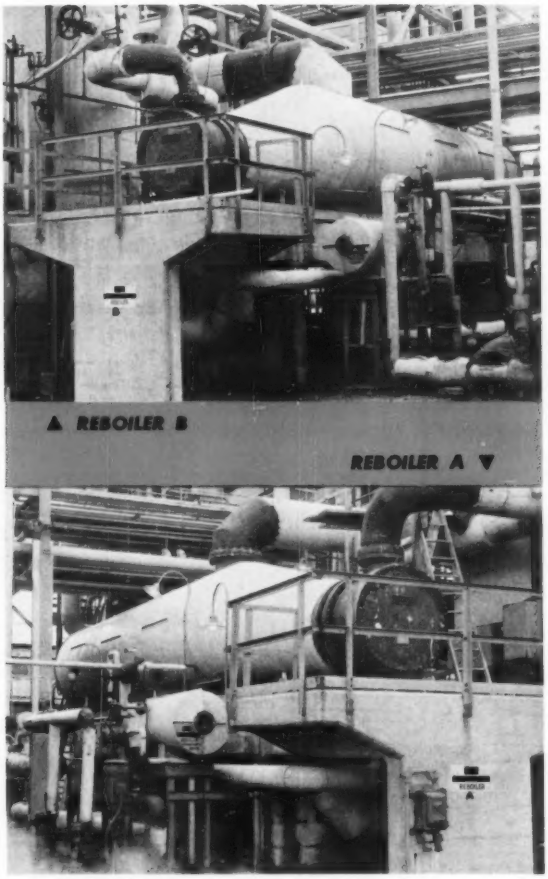
The Series 9,000 utility pump can be used for pumping slurry, proportioning chemicals, sump cleaning, recycling, clean-out service or handling corrosive fluids containing abrasives, fibrous materials or solids up to ¼ inch in diameter.

This new portable (weighs 70 pounds) air/gas-operated, double-diaphragm pump has no packing; requires no priming. Built in sections, the pump can be serviced "in-line,"



FRACTIONATING TOWER REBOILER COEFFICIENTS

Wolverine Trufin® Type S/T helps Sun Oil boost reboiler capacity



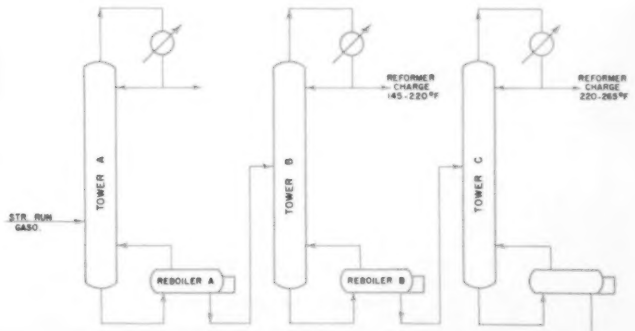
How Wolverine Trufin Type S/T—the integrally finned heat exchanger tube—boosts both tube surface area and heat transfer capacity is graphically shown by a recent Trufin installation at Sun Oil's Marcus Hook refinery.

In this application—preparing reformer feed stocks—two reboilers, tubed with bare tubes on triangular pitch, were retubed on a square pitch with Trufin Type S/T low carbon steel tubes in U-bend form.

Surface area in each unit jumped from 4400 to more than 9000 square feet. Following its retubing with 486 Trufin U-bends in June, 1959, the calculated overall coefficient of heat transfer in Reboiler B rose from a level of 60 on the bare tubes to 290 on the Trufin tubes and then, with normal fouling, leveled off at approximately 180—a threefold increase.

In the case of Reboiler A, which was retubed in September, 1960, with similar Trufin Type S/T U-bends, the calculated heat transfer coefficient rose from approximately 100 on the bare tubes to 180 on the Trufin tubes where it also leveled off.

Operations such as this, where excessive fouling on the outside of the tubes is normally encountered can, in many cases, be given a substantial performance boost through the use of Wolverine Trufin Type S/T. Why not get the Trufin story before retubing? Just ask your Wolverine salesman—HE KNOWS. Write, too, for a copy of the Trufin Catalog.



PREPARATION OF REFORMING CHARGE STOCKS

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. Q. 17236 SOUTHFIELD RD., ALLEN PARK, MICH.
TUBEMANSHIP in Copper—Copper Alloys—Aluminum—Special Metals

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
SALES OFFICES IN PRINCIPAL CITIES

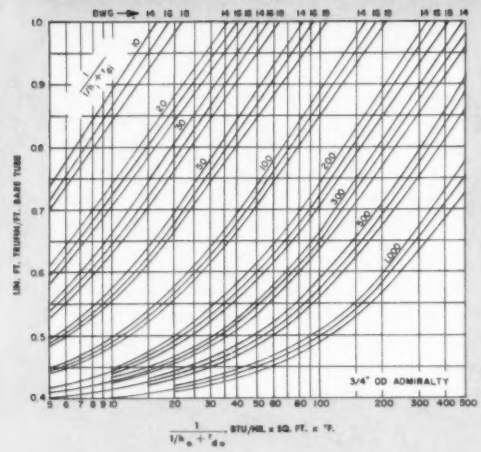


FIG. 4

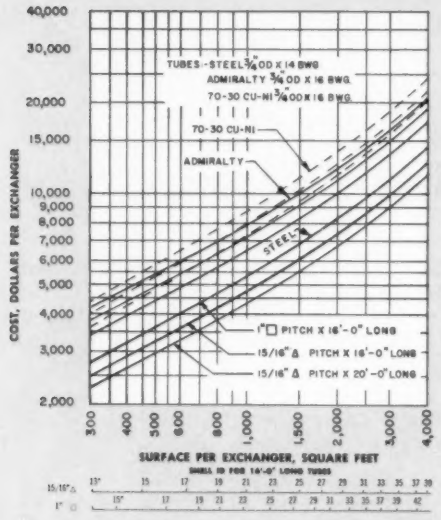

TUBES - STEEL 3/4" OD X 14 BWG
ADMIRALTY 3/4" OD X 16 BWG
70-30 CU-NI 3/4" OD X 16 BWG
70-30 CU-NI
ADMIRALTY
STEEL
1" □ PITCH X 16'-0" LONG
15/16" Δ PITCH X 16'-0" LONG
15/16" Δ PITCH X 20'-0" LONG
COST, DOLLARS PER EXCHANGER
SURFACE PER EXCHANGER, SQUARE FEET

FIG. 8

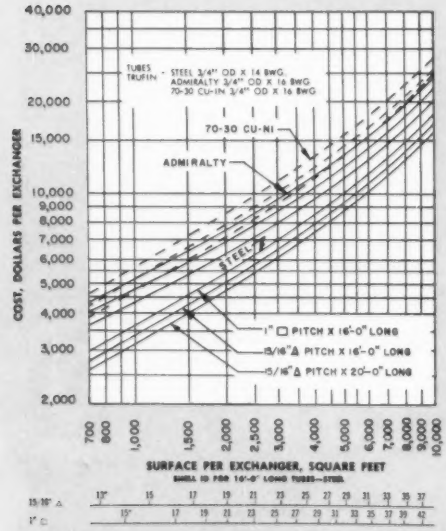

TUBES - STEEL 3/4" OD X 14 BWG.
ADMIRALTY 3/4" OD X 16 BWG.
70-30 CU-NI 3/4" OD X 16 BWG
TRUFIN
70-30 CU-NI
ADMIRALTY
STEEL
1" □ PITCH X 16'-0" LONG
15/16" Δ PITCH X 16'-0" LONG
15/16" Δ PITCH X 20'-0" LONG
COST, DOLLARS PER EXCHANGER
SURFACE PER EXCHANGER, SQUARE FEET

FIG. 10

Rate it for yourself!

Here's a "DO-IT-YOURSELF" test designed exclusively for technical people engaged in heat transfer operations. By using the technical data on this page, you can quickly make a comparison test that will show you the actual savings you can achieve by retubing bare-tubed heat transfer units with Wolverine Trufin® Type S/T—the integrally finned heat exchanger tube.

We're sure you'll be amazed when you see—for yourself—the savings Wolverine Trufin can bring your way. For more complete information write for a free copy of the Trufin Comparison Book, from which this data was taken or, ask your Wolverine Tube salesman—HE KNOWS!

ADMIRALTY TRUFIN

For a given service the calculated bare tube cooler contains 3100 sq. ft. in a 39" ID shell. Tubes are ¾" OD x 16 BWG x 16'0" long admiralty on 1" square pitch. The shell side coefficient and fouling factor were 150 and 0.002 respectively. The tube side coefficient and fouling factor for the water were 1000 and 0.001.

From *Fig. 8*, Cost=$16,400.

Refer now to *Fig. 4*

$$\frac{1}{1/h_o + r_{do}} = \frac{1}{1/150 + 0.002} = 115.5 \text{ Btu/hr x sq. ft. x °F}$$

$$\frac{1}{1/h_i + r_{di}} = \frac{1}{1/1000 + 0.001} = 500 \text{ Btu/hr x sq. ft. x °F}$$

From *Fig. 4*, 0.59 lin. ft. of Trufin are required per foot of bare tube. There are 0.1963 sq. ft./lin. ft. of ¾" OD bare tube.

From *Table 2*, there are 0.496 sq. ft./lin. ft. of ¾" OD Admiralty Trufin.

Trufin exchanger required=$3100 \times \frac{0.496}{0.1963} \times 0.59 =$ 4610 sq. ft.

From *Fig. 10*, nearest full shell 31" ID.

Surface = 4690 sq. ft.

Cost = $13,000.

Saving = $16,400 − $13,000 = $3,400.

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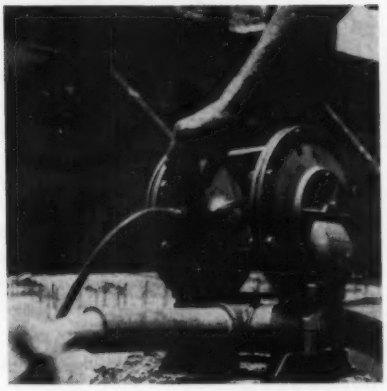
PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
SALES OFFICES IN PRINCIPAL CITIES

TABLE II

	NOMINAL SIZE		PLAIN SECTION DIMENSIONS		FINNED SECTION DIMENSIONS			OUTSIDE AREA	SURFACE AREA RATIO	I.D. CROSS SECTIONAL AREA
	O.D.	CATALOG NO.	O.D.	Wall Thk.	Root Dia.	Wall Thk.	Inside Dia.	Sq. Ft. per Linear Ft.	ao/ai	In Sq. Inches
19 FINS PER INCH	3/4	60-195028	.750	.049	.625	.028	.569	.496	3.33	.254
		60-195035		.049		.035	.555		3.41	.242
		60-195042		.058		.042	.541		3.50	.230
		60-195049		.065		.049	.527		3.60	.218
		60-195065		.083		.065	.495		3.84	.192
		60-195083		.095		.083	.459		4.13	.166



without removing the suction or discharge lines.

The pump provides smooth, accurately controlled discharge from 1 to 60 gallons per minute through a 2-inch discharge outlet . . . even operates completely submerged. Real lifting power, too . . . lifts fluid 14 feet without a foot valve.

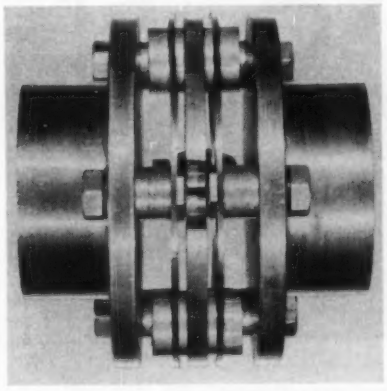
Complete catalog and application data available. Texsteam Corp.

Circle E10 on green card, last page

Power Coupling Said To Be Cheapest in the World

A new series of all-metal, flexible, power transmission couplings, specially designed for light duties and claimed to be the cheapest couplings of their type in the world is called the "DIS" series.

The couplings can be used wherever power has to be transmitted in a range from 1 hp per 1,000 rpm to



40 hp at 1,000 rpm or 80 hp at 2,000 rpm.

The coupling will compensate for misalignment and axial deflection and will not transmit thrust. The secret is in the stacks of stainless steel discs, each only .005 inch thick, riveted to-

SERIES 300 PROPORTIONING PUMPS

ADJUSTABLE IN OPERATION FROM ZERO TO FULL CAPACITY

The unique control mechanism on American's new 300 Series Pumps provides full range adjustment while the pump is operating. Capacities range from 1 to 812 gallons per hour on the simplex series and from 2 to 1624 gallons on the duplex series. Maximum working pressure is 10,000 PSI. For maximum versatility and absolute minimum maintenance the Series 300 also incorporates these quality American design features:

- Interchangeable liquid ends.
- New cam adjustment mechanism controls pump plunger stroke from any point from zero to maximum output.
- Compact housing — all moving parts enclosed.
- E-Z Clean Cartridge Valves for simple maintenance.
- Plunger (diameters from ¼" to 2¾") serviceable without disturbing the adjustment mechanism.

For use in high-corrosion environments, new Series 300 American Pumps are available with plungers and liquid end made in either ceramics, chrome plate or stainless steel. Remote or automatic controls are also available. Write American Meter Company for full details.

AMERICAN® METER COMPANY
INCORPORATED ESTABLISHED 1836
pump division
13500 PHILMONT AVE. PHILADELPHIA 16, PA.

For more data on advertised products, use cards, last page.

gether and assembled into an integral membrane unit. Engineering details available. Metaducts, Ltd.

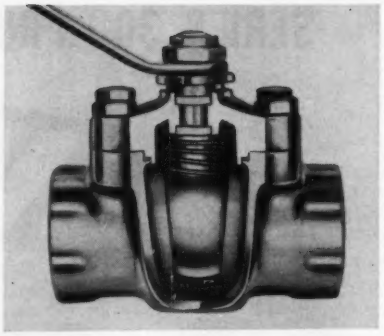
Circle E11 on green card, last page

Ball Valves Can Be Used To 1,000 °F With New Seats

Use of Graphitar seats in "McCannaseal" ball valves permits their use at temperatures to 1,000° F when handling non-oxidizing liquids or gases, and to 700° F for oxidizing reagents. Heretofore, the maximum temperature limit for a ball valve was 600° F, using a reinforced Teflon seat with a metal containing ring.

Allowable maximum pressure at higher temperatures is dependent upon the valve body materials. At 1,000° F, bodies of 316 stainless steel, 300-pound ASA rating, are suitable for pressures to 355 psig; carbon steel for pressures to 80 psig. The same materials in 150-pound ASA rating valves are suitable for pressures to 40 psig at 1,000° F.

Higher pressures are permissible at lower temperatures. For example, 300-



pound ASA rating stainless steel bodies can be used at 490 psig, 700° F.

The use of non-resilient, high-temperature Graphitar seats is possible by a spring which forces the ball downward into a "wedge-seat" arrangement. The resulting high mechanical advantage insures leaktight closure.

The valves are available with screwed and socket-weld end connections in 1 through 3-inch sizes, and with 150-pound or 300-pound ASA flanged ends in 1 through 8-inch sizes, either manually or pneumatically operated. Hills-McCanna Co.

Circle E12 on green card, last page

Unique Airstream Equipment Cuts Refinery Fire Loss

During the afternoon and evening of December 3, 1960, two 72-inch air units played an important part in controlling the Rothchild refinery fire. This date marked the first time in the history of fire control that such equipment was used, resulting in complete elimination of such hazards as conduction, convection, and radiation on that portion of the firefront it was directed against. Water in the form of "fog spray" was also effectively dispersed over 500 feet distant, covering an area some 300 feet wide, during this operation.

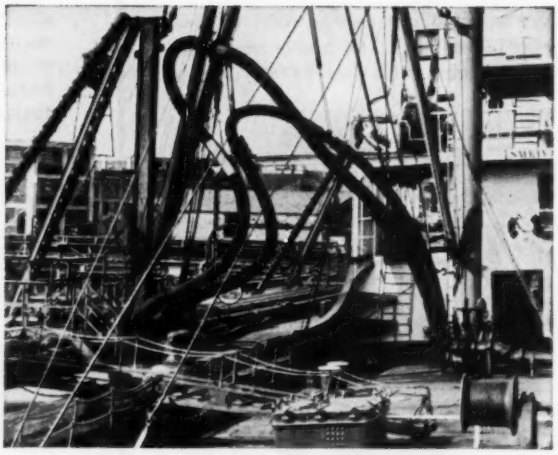
Thousands of gallons of high octane gasoline were burning and storage tanks exploding—a fire storm condition existed with adverse, gusty 10-mile-per-hour southwest winds prevailing, when the air units began generating and controlling a favorable counter-draft, over the tanks which were adjacent on the northeast, and along side of the exposed south side of the cracker plant, north of the fire.

Dry airstreams were effective during the first two hours of the fight and

ONLY R/M PARANITE LOADING HOSE OFFERS ALL THESE LONG-LIFE FEATURES

- **HYCAR TUBE**—Oil-Proof and High-Octane Resistant.
- **UNIFORM BORE**—assures Rapid Flow—Suction or Discharge.
- **NEOPRENE COVER**—Oil, Abrasion and Weather Resisting for Long Wear.
- **TYPE "C" LEAK-PROOF FITTINGS**—Built into the hose as an Integral Part—*no clamps required.*
- **SQUARE-WOVEN DUCK PLY CONSTRUCTION**—engineered for *Safe* Flexibility and Stress Resistance under Pressures.

Reduce dock time with the combination suction and discharge hose recognized for the highest standards of performance, safety and long service life. Available in 7 types for pressures up to 200 psi—smooth-bore, rough bore, for sea and dock ship loading and barge service. Ask about the Paranite Loading Hose construction engineered for *your* operations . . . and other performance-proved R/M products for the petroleum industry.



R/M ROTARY HOSE / MUD PUMP INTAKE HOSE / VIBRATION HOSE / NON-BURSTING STEAM HOSE / PILE DRIVER HOSE

RM 107

RAYBESTOS-MANHATTAN, INC.
MANHATTAN RUBBER DIVISION • PASSAIC, N. J.
ENGINEERED RUBBER PRODUCTS

then the wind changed to the south. A request was made for water to be introduced into the airstreams to give them weight. This request was granted and the moisture-laden airstreams soon penetrated the then existing four to 10-mile-per-hour crosswinds, so the northeast edge of the column some 200 feet away was bent directly into the cracker plant. Shortly thereafter, the column was bent west because the controlled airstreams, laden with moisture, were regulating the atmospheric pressures. The fire's ability to generate energy was reduced through the "indirect attack method." And since the fire's updraft was under control, volume and velocity of the indraft was automatically controlled, and the same effect was obtained as turning a damper in a stove to stop it from drawing.

Fire companies succeeded in closing the valves so the fire was not pressure fed, and the fog-spray-laden airstreams traveling over the combustion area, resulted in the fire causing a weak explosion in or around one of the tanks, which blew the fire out.

This fire proved that dry controlled airstreams are safe, effective, and capable of eliminating the danger of conduction, convection, and radiation.

This operation also proved that water introduced into the airstreams can be changed into fog spray, and dispersed hundreds of feet distant through cross-wind.

Complete details on the units are available. Controlled Airstreams, Inc.

Circle E13 on green card, last page

How to Get New Life Out Of Old Cooling Towers

"New Life for Old Cooling Towers" is the title of a new eight-page brochure describing various types of chemical and biological deterioration, primary causes of this attack and the recommended treatment.

Before and after photos of actual case history repair jobs illustrate what can be done when a tower no longer has the cooling capacity to meet expanded plant operations, and when a tower is severely damaged by fire or other causes. Numerous design features are listed which can be used in existing towers in the course of repairs and modernization, resulting in greater operating economy and increased tower efficiency. This informative brochure is free upon request. Fluor Products Co.

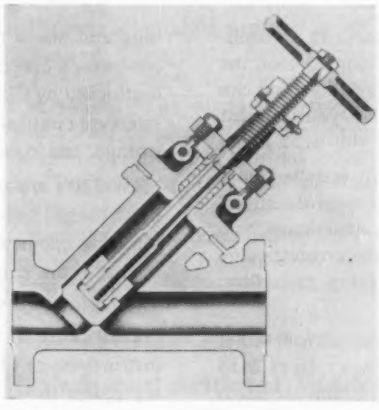
Circle E14 on green card, last page

'Y' Valve Inner Surfaces Completely Plastic Coated

A new valve, especially designed and made to combat destructive effects when controlling the flow of corrosive fluids, is a metal, plastic-lined "Y"-type valve.

All wetted or inner parts and surfaces (inside surface of body and bonnet stuffing box and stem) are protected by a heavy lining, as shown in illustration. Three plastic materials are available, the most feasible one to use being determined by the service for which the valve is required, as well as the pressure and temperature of the corrosive fluid to be handled.

While these valves usually are cast carbon steel, they can be supplied in other alloys on special order. They



are presently made in sizes from 1 through 3 inches, with dimensions conforming to ASA Standard B16.5 for 150 psi. Complete illustrated literature available. The Wm. Powell Co.

Circle E15 on green card, last page

R/M CAPABILITY PRODUCES VEE-SQUARE® PACKINGS

to eliminate sensitive gland adjustments

R/M Vee-Square Packings combine the advantages of jam type packing rings with the automatic sealing of V-ring design. They take tight gland pressure, require no sensitive adjustment. And blowby is prevented by the soft rubber cushions between rings. Each ring in a set acts individually during normal life and pressure does not pyramid.

Write for your copy of "R/M Products for the Petroleum Industry," Catalog P-8904, covering Vee-Square and other mechanical packings.

RAYBESTOS-MANHATTAN, INC.
RM PACKINGS
PACKING DIVISION, PASSAIC, N.J.
MECHANICAL PACKINGS AND GASKET MATERIALS

Low Cost Computer for the Process Industries

A sophisticated low-priced control computer with capabilities ranging from simple logging to closed-loop control, the TRW-330 brings you a new standard in flexibility. You can start with a small basic system that matches your current requirements and then add capabilities as you need them.

Thompson Ramo Wooldridge has successfully installed more digital control computers than any other manufacturer. Because TRW-330 design is based on this experience, you are assured that a TRW-330 system offers the greatest value per dollar in computer hardware – in flexibility, reliability, efficiency.

TRW-330 FLEXIBILITY – Memory sizes range from 4,000 to over 100,000 words; analog input capacity from 0 to over 1,000; an optional subsystem permits automatic scanning and alarm functions to proceed independently of the computer's control program. A similar degree of flexibility is afforded by the TRW-330's analog-output system, priority interrupt circuits, digital input-output equipment, fast-access storage, and command structure.

TRW-330's are supplied in cabinets that match the application: rugged cabinets for harsh industrial environment, air purgable cabinets for hazardous environment, or standard control-room cabinets.

TRW-330 CAPABILITIES – TRW-330 computing speeds exceed those of competitively priced machines; addition instructions can be performed in 260 microseconds, including access time.

TRW Computers Company

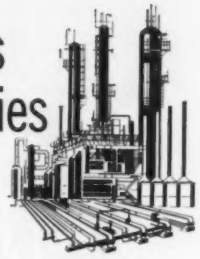
a division of *Thompson Ramo Wooldridge Inc.*

TO FIND OUT HOW THE TRW-330 CAN BE APPLIED TO YOUR CONTROL PROBLEM, CONTACT ANY OF THE TRW COMPUTERS COMPANY OFFICES LISTED BELOW.

220 North Canon Drive	1510 Esperson Building	200 East 42nd Street	200 South Michigan Avenue	3272 Peachtree Road, N.E.
BEVERLY HILLS, CALIFORNIA	HOUSTON, TEXAS	NEW YORK 17, NEW YORK	CHICAGO, ILLINOIS	ATLANTA 5, GEORGIA

TRW-330 applications in the process industries

13-6A



Since the 1959 installation of a TRW digital computer for control of a cat-poly unit, eleven TRW computer systems have been purchased or are in use by the chemical, petrochemical, and petroleum industries.

Maintaining leadership in the field of automatic process control, Thompson Ramo Wooldridge now offers the TRW-330 for any control job — large or small. Because the TRW-330 is flexible in size, you pay for only as much computing and control capacity as you need, but can later expand your system for data logging and closed-loop control of additional plant units.

The TRW-330 is ideal for an "evolutionary" control system. Placed on-line as a data logger for a minimum initial investment, the TRW-330 can be used to gain process knowledge by collecting and analyzing operating data. You can then expand your TRW-330 to closed-loop control.

The experience of Thompson Ramo Wooldridge is your guarantee in both hardware and systems engineering. Investigate the TRW-330 in the light of your own requirements today.

TRW Computers Company

a division of Thompson Ramo Wooldridge Inc.

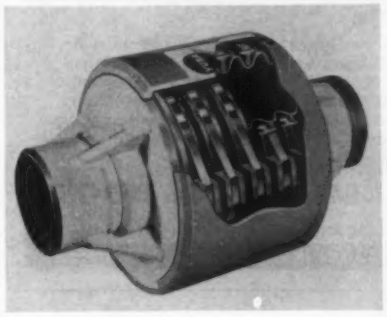
8433 FALLBROOK AVENUE, CANOGA PARK, CALIFORNIA

New Equipment . . .

Only Axial Movement in Bellows Expansion Joint

A bellows-type expansion joint which is rigid against all movement except axial and which creates minimum friction along the guiding surfaces is offered in two models: the Corruflex externally-guided model (see photo) the Corruflex internally-guided model.

Whether internal of external, the guide is of heavy, dependable construction, welded strongly to the body of the expansion joint. In the internal application, a guide ring carefully welded to the inner slip rides



smoothly, concentrically, and with little friction along the machined bore of the body to insure true and axial movement. When the guide is external, the machined guide surfaces of the equalizing rings move smoothly and evenly in the bore of the external guide.

Because all guiding surfaces in both expansion joints have been finished to close tolerances, friction is held to a minimum. The joints thus operate easily with no danger of the piping being strained as the thermal expansion forces try to overcome the friction forces.

Both joints are described in a new bulletin which is available. ADSCO Div., Yuba Consolidated Industries, Inc.

Circle E16 on green card, last page

High Speed Actuator Works Well in Fuel Blending

A new 20,000 Series electrohydraulic actuator offers extremely fast speed, high frequency response, good positional accuracy and large thrust.

The THA-1 actuator provides a means of converting a suitable elec-

. . . one of a series presented by Western Supply Company, Tulsa, to improve the "I.Q."* of engineers . . . (*"Income Quotient")

Personal, professional advancement demands thorough engineering knowledge, disciplined habits, creative thinking, constant application

"Intellectual let-down" — that tendency so common to many engineers to "stop learning" as soon as they acquire a sheepskin — will be completely out of style by 1999. Indeed, it is passe in today's accelerated engineering profession, because to stop learning is to stop growing; to stifle imagination, to throttle creativity, and ultimately to kill scientific progress.

The engineer who would keep pace with his own industry — especially the process industry — must determine to follow a prescribed, disciplined course of action, if he is to achieve the stature, prestige, responsibility and income to which he aspires. He must recognize that only as his engineering achievement advances will his personal well-being also increase.

There is no magic formula for the "successful engineer," but for what they are worth to your professional future, here are 14 "ground rules" for your consideration:

Set objectives for your professional and personal life, re-examine them periodically, but always work towards a goal in life.

Develop sound work habits. Earn a reputation for promptness, attention to detail, accuracy, diligence, reliability.

Continue to study your chosen field or specialty. Your learning process must never cease functioning.

Seek additional training, technically or in non-technical fields which can be of importance to future development.

Think creatively about your job, your company, technological advances and developments. Dare to think **beyond** your capacity.

Expand your capacity to discover new fields of endeavor, discriminatingly, however, so that they will have application to your objectives.

Take a genuine interest in people, their potentials, their problems. Understand, but don't condemn, their shortcomings.

Broaden your base of appreciation for other pursuits, such as sales, accounting, law, advertising. They, too, are important to your company.

Study the fundamentals of business. Learn the economics of your company, its basic philosophy, its obligations and responsibilities, its opportunities and limitations.

Seek advice and counsel from others; don't rely entirely on your own resources . . . Ask questions.

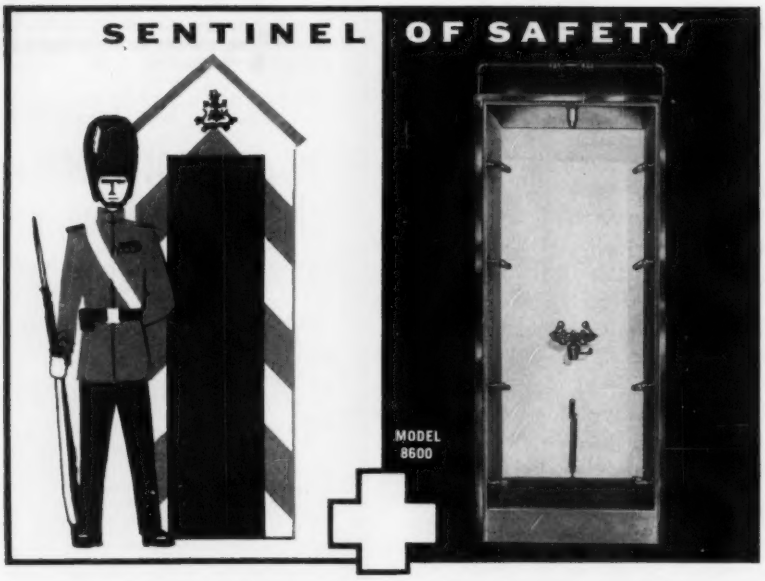
Participate actively in technical societies; keep alert to professional trends, changing concepts, new developments.

Use common sense and sound, practical judgment in evaluating everything from people to processes.

Aggressively pursue your professional and personal ambitions, but with patience and intelligence.

Learn to communicate your ideas and opinions pleasantly, clearly, concisely, aggressively to your superiors, associates, subordinates.

The development of a successful career in engineering requires **constant, consistent dedication** to professional and personal principles. These few paragraphs may serve as a guide for your own advancement and future, but for a more detailed discussion on this topic, write for your free copy of Booklet E-2, "Personal, Professional Advancement," to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and if there's a heat exchanger in your company's future, we'd like to demonstrate how these same "ground rules" affect our heat exchangers.



On guard just in case! When trouble strikes, emergency action must be *immediate*. Contamination from acids, chemicals and other industrial caustics requires first aid *now*... HAWS Decontamination Booths are your best stand-by protection against serious injury. MODEL 8600: Fiberglass decontamination booth; spray nozzles and eye/face wash activated by weight on treadle base.

Since 1909 HAWS **DECONTAMINATION BOOTH**

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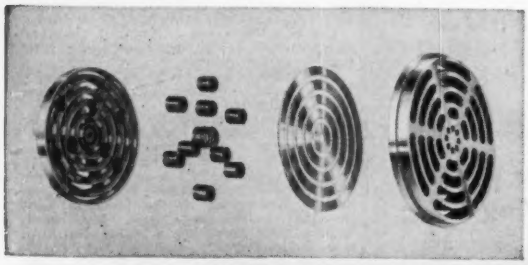
HAWS DRINKING FAUCET COMPANY 1443 Fourth St., Berkeley 10, California

VOSS VALVES will mean LESS MAINTENANCE FEWER SHUTDOWNS for your COMPRESSORS

Voss Valves are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. Plates are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable... ductile... resist fracture, high temperatures and corrosion... withstand fatigue. Springs of heavy rectangular sections and large diameters add to dependability and safety.



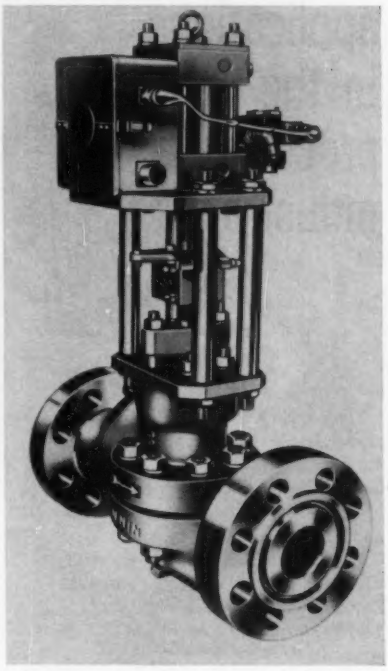
- **up to 40% more valve area**
- **minimum pressure loss**
- **higher efficiency**
- **less power consumption**
- **normal discharge temperature**
- **quiet, vibration-free**
- **utmost safety**
- **lower operating costs**

For detailed proposal send name, bore, stroke and speed of machine.

J. H. H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street,
New York 54, N. Y.

New Equipment . . .



trical signal from an automatic or manual electrical control station to a powerful hydraulic force. The actuator is responsive to minute rapid changes in electrical signals and delivers instantaneous action while remaining inherently stable under adverse operating conditions.

The actuator has been test-proven with polyethylene reactor let-down valves and fuel blending systems requiring fast speed and frequency response. Engineering details are available. The Annin Co.

Circle E17 on green card, last page

Mitered Bends for Aluminum Insulation Jacketing

A new technique in applying jacketed pipe insulation allows job-site fabrication of aluminum-covered elbows, turns, sweeps, and bends directly from straight lengths.

The use of Miter-Seals for angle insulation eliminates the many complex operations previously necessary for insulating fittings and bends, as well as stocking and storage problems with pre-formed humped elbows and fitting covers. Miter-Seals, available for use with pipe sizes from ¾-inch up to 24 inches, allow application of jacketed insulation in many cases

accuracy

ASHCROFT DURAGAUGES measure pressure with precise accuracy no matter how severe the conditions of service

Ashcroft Duragauges are available in pressure ranges from 15 psi (or vacuum) minimum to 100,000 psi. Dial sizes: 4½" through 12".

sustained

The Bourdon tube in Ashcroft Duragauges is manufactured to precision standards of flexibility and mono-linked to the rotary movement. When pressure flexes the tube, the gauge pointer is always positively positioned, because it is mounted on the geared center shaft of the movement. Sustained high accuracy and long life are assured.

Choose your Ashcroft Duragauges made of components best suited to your needs. Eight Bourdon tube materials are available. Movement of stainless steel with nylon bearings and pinion gear for longest wear. Case materials: special aluminum alloy or tough phenol plastic.

The unique "Maxisafe®" Duragauge provides absolute protection to the viewer, plus easy and quick access to the mechanism. Your industrial supply distributor will help you select the best combination of components for your Ashcroft Gauge requirements. Phone him today or write for Catalog 300B.

MANNING MAXWELL & MOORE INC. TRADE MARK

ASHCROFT PRESSURE GAUGES

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut

Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
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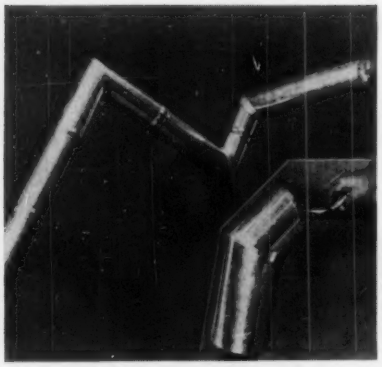
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

For more data on advertised products, use cards, last page.

New Equipment . . .



where it was not possible except on straight runs.

Fabrication of insulation for a fitting requires only a few steps, using a straight length of the same metal-on being used for straight runs, an ordinary saw, a Miter-Seal band, and a banding wrench. Instructions provide the precise measurements and angle cuts to be made with each pipe size and insulation thickness, thus removing all guess-work and minimizing measuring operations.

Additional data on the new Miter-Seal and metal-on insulation system are available. Johns-Manville.

Circle E18 on green card, last page

8, 10, 12-inch Plug Valves Have Plastic Sleeves

New 8, 10 and 12-inch plug valve designs have specially-tempered Teflon sleeves with sculptured body bore to insure bubble-tight sealing even on temperature fluctuating service. Absence of sediment-catching flow pockets, quick, easy operation (manual or automatic), and wiping action of the sleeve on the plug as it rotates to keep it clean and free of adhering solids or liquid films are other features.

The valves are gear-operated, have flanged ends, and are rated at 150 and 300 pounds for service within temperature range of —50° F to +400° F. They can handle a wide range of media from light gases to heavy slurries and corrosives. They are available in two-way or three-way bottom entry types with bodies and plugs of Alloy 20, 316 S.S., and carbon steel bodies with stainless steel plugs (ductile iron plugs are available in two-way types). On special order, they are also available in other metals, such as bronze, Hastelloys, Monel and nickel. Continental Manufacturing Co.

Circle E19 on green card, last page

Castable Refractory Is Dual Purpose Product

A unique, new refractory castable material, called One Shot, is designed primarily for use by the oil and chemical industries. It combines into one product the more important characteristics of a high strength castable and an insulating concrete.

For many years the practice in lin-

MODEL 9B PYROTEST

The Most Versatile Portable Potentiometer Made

- **Checks any thermocouple-actuated instrument**
- **Guaranteed accuracy— ⅛ of 1%.**
- **9 interchangeable, direct-reading scales**

Pyrotest is the only portable potentiometer that can check any thermocouple-actuated indicator, controller, or recorder. It comes with 6 thermocouple scales and 3 MV scales—as easy to change as phonograph records. Scale length of over 4 feet, with high resolution to match. Pyrotest is so accurate, it's used as a standard in the lab . . . so versatile and rugged, it's used as an all-purpose tool everywhere in the plant. Only $315.00, fob Indianapolis. Write for free Bulletin 9-B.

TECHNIQUE

TECHNIQUE ASSOCIATES

A Division of Duncan Electric Co., Inc.

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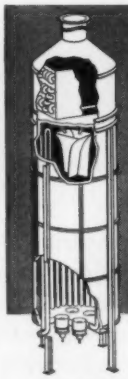


Get top efficiency in industrial process heating

"HI-TURBIANT" HEATERS

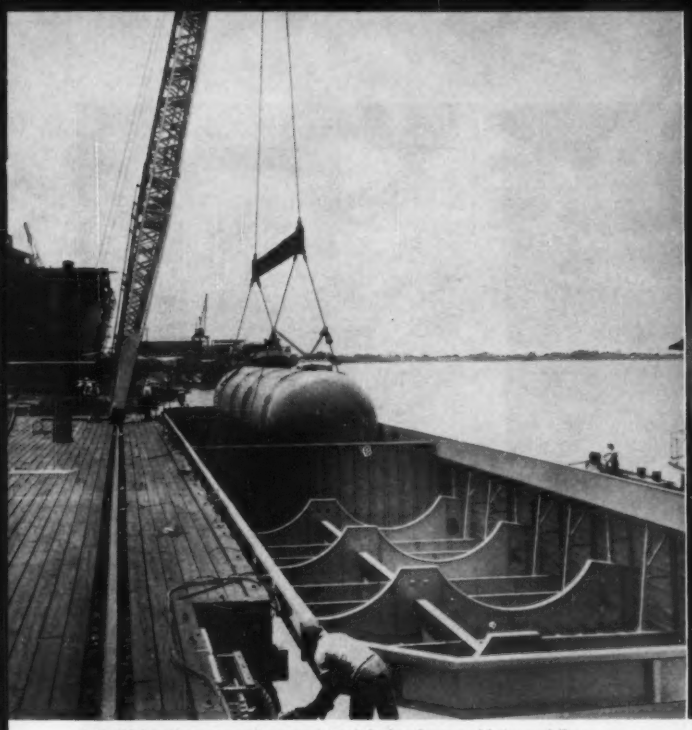
Direct-fired process streams (and heating transfer fluids) get hot efficiently — **fast** and **economically** — when a Western Precipitation "Hi-Turbiant" Heater does the job.

A unique and exclusive reradiating baffle is the secret. It assures optimum heat absorption . . . and permits a greater height-to-diameter ratio that keeps friction losses low — pumping efficiency high — and saves floor space. Full range of sizes — 250,000 to 40-million BTU/hr.

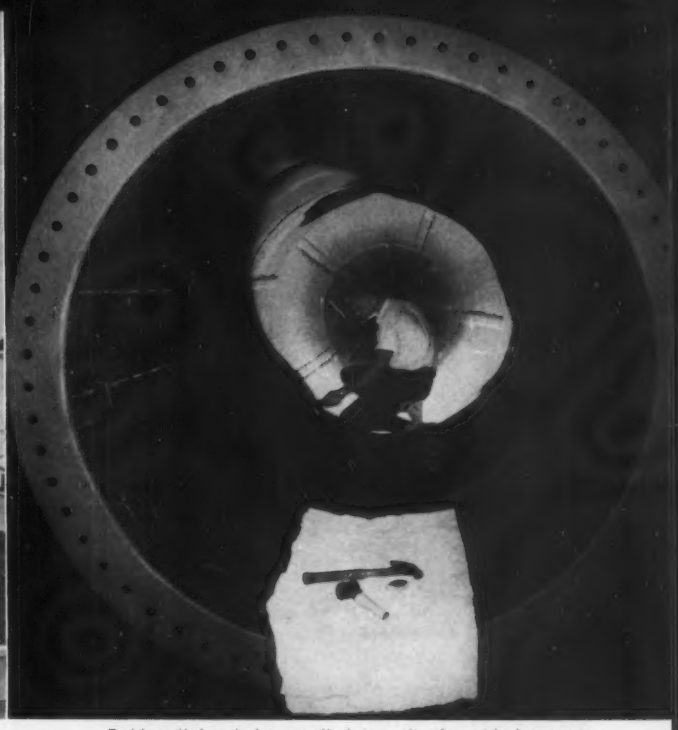
WANT DETAILS? For literature, write Western Precipitation, 1000 W. 9th St., Los Angeles 54, Calif. (In Canada, write 8285 Mountain Sights Avenue, Montreal, P. Q.)

WESTERN PRECIPITATION

DIVISION OF JOY MANUFACTURING COMPANY



165,000 gallon capacity cargo tank being lowered into saddles in petrochemical barge hull. Lifting device (partly shown) has 600 ton capacity.



Rubber lining being applied to unit of a chlorine system. Flow meters, valves and tanks are lined with speed and efficiency. Avondale is the authorized U.S. Rubber Co. applicator for N.W. Fla., Ala., Miss., S.W. Tenn., Ark., and La.

AVONDALE

BUILDS and DELIVERS

THE MACHINERY OF PETROCHEMISTRY

From giant tank carrier barges to the smallest anticorrosive rubber lining job, Avondale builds and delivers the machinery of petrochemistry. Specialized engineering ability, shop facilities and fabrication skills assure custom construction to *your* specifications—Avondale is continuously aware of the special requirements of the petrochemical industry. And Avondale's strategic location permits fast delivery by truck, rail or barge.

Contact Avondale today about your next project. Use our skills and ability to *your* advantage.

AVONDALE SHIPYARDS, INC.

P. O. BOX 1030 • PHONE UNiversity 6-4561 • NEW ORLEANS 8, U.S.A.

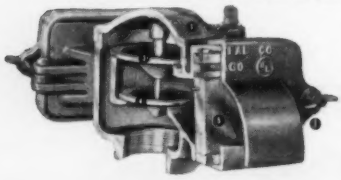
◀ Weather and corrosion-resistant fire hose house. The Avoncraft Division produces these and other porcelain enamel on steel products including lagging and buildings of all descriptions.

Ethylene storage tank for a large chemical company, shipped by rail. Avondale fabricates pressure vessels and storage tanks in the Main Yard, the strategic location of which permits delivery by truck, rail or barge. ▶

Protectoseal conservation Vents incorporate unique design and operating features to ensure optimum service on flammable or hazardous liquid storage tanks of every type.

● FLAME ARRESTER DESIGN

Vertically mounted rectangular plate type flame arrester structure is *outside* the housing. Advantages:



1 Pressure tight Aluminum alloy casting
2 Wing Nut on Swing Bolt
3 & 4 Pressure and Vacuum Relief Valves
5 Flame Arrester Structure

1. In the event of fire, the vent burns *at the arrester*, rather than at the valves. This eliminates heat warping or distortion of the valve mechanism.
2. Dirt and other foreign particles cannot reach valves, to cause improper seating.
3. Flame arrester is exposed to corrosive vapors on exhale cycle only. This keeps arrester plates clean longer, requires less maintenance.
4. Self-drainage of condensate.

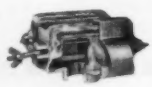
The interchangeable flame arrester structure is made of heavy gauge metal to resist damage, bending or warping. Accurate, positive air-spacing assured upon re-assembly by embossings on the face of each plate.

A spare arrester can be inserted to safeguard tank interior while original arrester is being cleaned and serviced. Loosening wing nut and pushing swing bolts aside permits quick, easy removal of flame arrester structure.

Pressure and vacuum relief valves in Protectoseal Conservation Vents may be fabricated to relieve at settings required by your operating conditions. When severe corrosion is present, the vent housing, valves, and flame arrester structure may be fabricated from special corrosive-resistant metals. Teflon valve seats may also be provided.

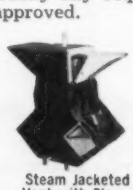
Conservation Vents are made in a range of sizes to meet virtually any requirement. UL and FM approved.

OTHER PROTECTOSEAL EQUIPMENT FOR STORAGE TANK OPERATION

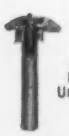


End-of-Line Flame Arrester Vent

In-Line Flame Arrester Vents



Steam Jacketed Vent with Flame Arresters



Combination Fill and Vent Units, Fill Units

Combination Vent Rodding and Sampling Units

Emergency Relief

Write for the Protectoseal Blue Book. Illustrates and describes complete line of Protectoseal Products for hazardous liquid storage tank application.

THE PROTECTOSEAL COMPANY
1942 SOUTH WESTERN AVE. • CHICAGO 8, ILLINOIS

New Equipment . . .

ing reactor and regenerator linings of catalytic crackers has been to use a dual lining—one, a lightweight insulating refractory material and the other a hardfaced, dense castable material. One shot provides the important characteristics of both linings in one, having good strength to resist abrasion and erosion, and moderate density to reduce heat losses.

The product may be cast or it may be gunned in place with a rebound loss of less than 10 percent. One Shot offers economic advantages because it not only reduces installation costs but requires less reinforcing steel to hold the single lining in place.

In catalytic cracking units, the material can be used successfully in the regenerator cone sections of fluid catalytic cracking units, in the main areas of cat cracker reactors and regenerators, in vaporizor towers, heaters, stacks, ducts and breachings. Kaiser Refractories & Chemicals Division.

Circle E20 on green card, last page

Temperature Transmitter Specs Given in Bulletin

Described in a new bulletin is the Type 12A pneumatic temperature transmitter which features compact construction, force-balance operation, and—to sustain measurement accuracy—automatic compensation for ambient temperature and pressure changes.

The 12-page bulletin illustrates how easily the transmitter can be installed and adjusted to suit a wide range of application requirements.

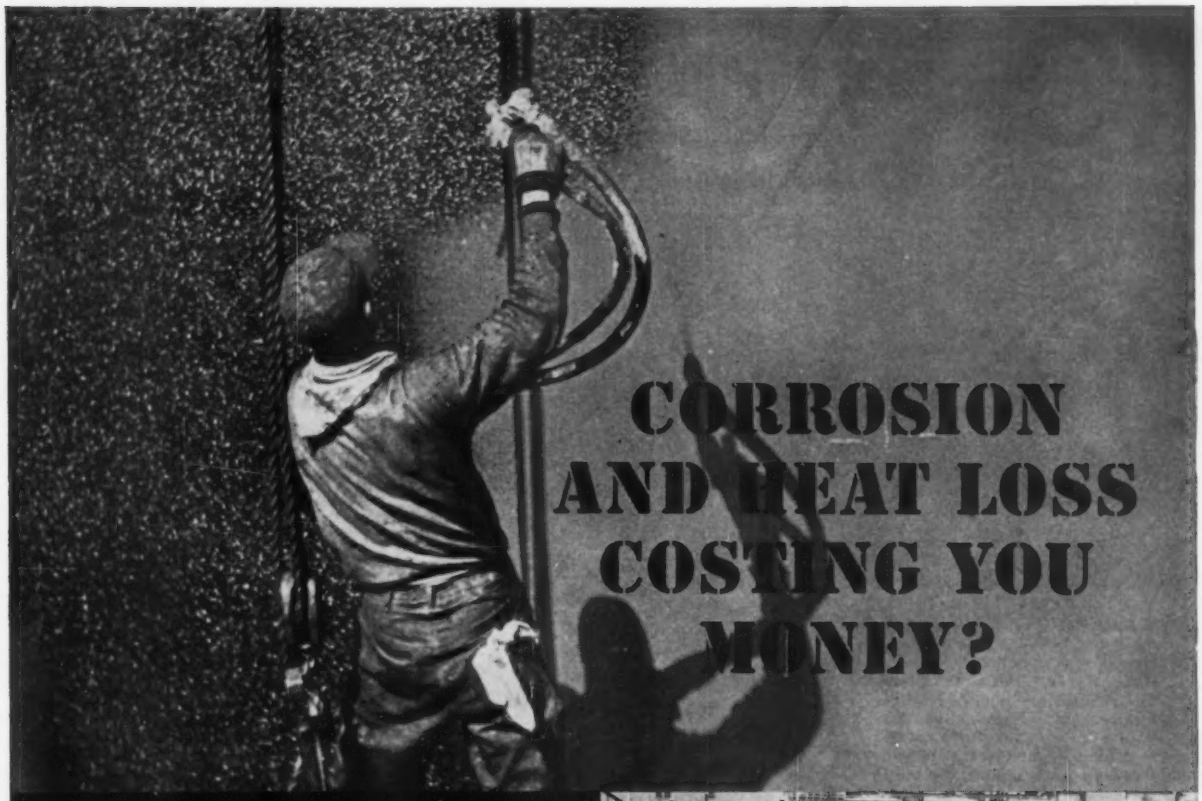
Also included are detailed specifications, descriptions of operating principle, table of temperature ranges, and data on related accessories. The Foxboro Co.

Circle E21 on green card, last page

4-Pen Recorder Solves Design Space Problems

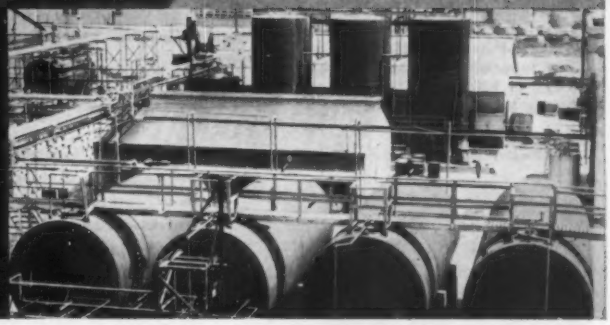
A new 4-pen Electronic Dynamaster Recorder is ideally suited where space is a problem, or where four simultaneously recorded variables must be compared on a time basis. The new instrument is actually four instruments in one case.

It will record any set of variables that can be transduced into an electrical quantity. Each pen has its own



CORROSION AND HEAT LOSS COSTING YOU MONEY?

PROTECT AND INSULATE IN ONE APPLICATION



You can effectively protect and insulate storage tanks, buildings and other structures, whether metal, cement, brick or other materials, against corrosion, abrasion, weathering and the harmful effects of sunlight. Here are two economical products that will be of interest to you.

Pioneer Cork Insulation, for example, is a cold applied, bituminous-base composition containing cork and asbestos fillers for lasting efficient protection and insulation of heated outdoor storage tanks. Fuel savings alone usually recover cost of application in one winter's time. **Pioneer Vapor Seal** is a carefully selected blend of asphalts and other resistant materials that provide long-lived protection for all types of structures with easy, economical application. Colored slate or ceramic granules may be added to enhance surface beauty.

Interested in further information? Just fill in and send coupon.

PIONEER PRODUCTS DIVISION
WITCO CHEMICAL COMPANY, INC.
122 East 42nd Street • New York 17, N. Y. Dept. 82-03

I would like information on protective and insulating coatings for the application listed below: Please send ☐ Samples ☐ Representative

Application_____

_____

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

TO PROTECT OR INSULATE ANY STRUCTURE . . . ANY SURFACE, WITCO MANUFACTURES A COMPLETE LINE OF PIONEER ASPHALT AND ASPHALTIC SPECIALTY PRODUCTS

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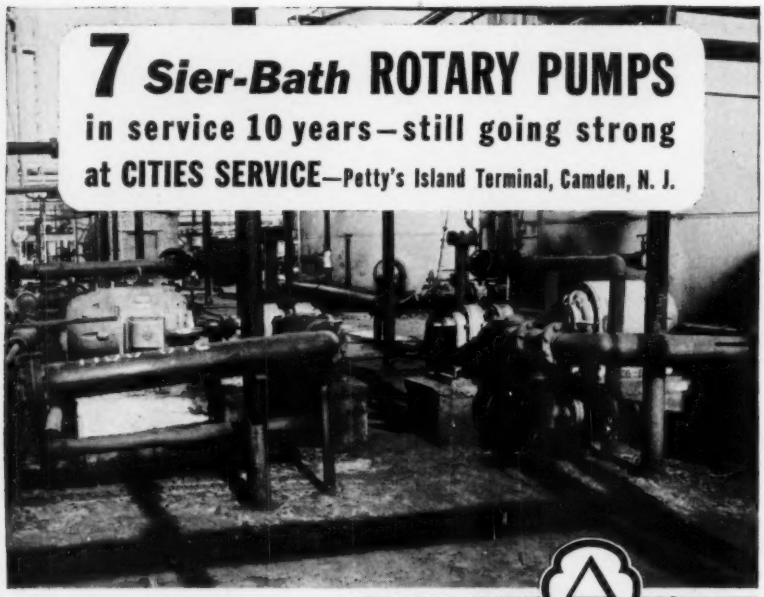
WITCO CHEMICAL COMPANY, INC.
PIONEER PRODUCTS DIVISION
Dept. 82-03, 122 East 42nd Street, New York 17, N.Y.
Sales Offices: New York • Chicago • Los Angeles • Toronto and Montreal, Canada

QUALITY PIONEER PRODUCTS

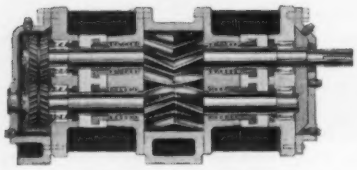
7 Sier-Bath ROTARY PUMPS

in service 10 years—still going strong at CITIES SERVICE—Petty's Island Terminal, Camden, N. J.

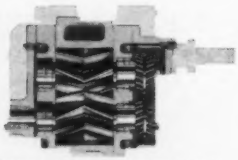


● Operating one to three hours daily since 1950 in lube oil transfer and tank truck loading service, these Sier-Bath GEAREX Rotary Pumps continue giving excellent service. The pumps deliver 300 gpm. of lube oil ranging from 500 to 3,000 SSU at 30 to 115° F., with flooded suction against discharge pressure of 75 psig. Also in operation, are several Sier-Bath Screw Pumps handling 500 gpm. of lube oil stock having 10,000 SSU at 130° F., discharging at 90 psig with flooded suction.

Sier-Bath "Gearex" Pumps



EXTERNAL GEAR & BEARING TYPE
for non-lubricating liquids



INTERNAL GEAR & BEARING TYPE
for lubricating liquids

Sier-Bath "Gearex" Pumps provide positive displacement, pulseless flow . . . quiet, vibrationless operation. Direct-connected up to 1800 RPM, they require no reduction gears. For high volumetric efficiency and long life there is no rotor-to-rotor or rotor-to-casing contact. Low pressure on stuffing boxes provides easy servicing.

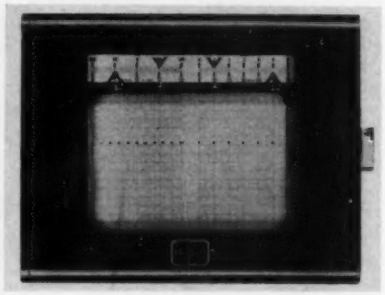
Horizontal or vertical models to handle 32 to 5,000,000 SSU, 1 to 650 GPM, at pressures up to 350 psi. Corrosion-resistant alloys, steam-jacketed bodies, water-cooled bearings, other adaptations to meet individual needs. See "Yellow Pages" for your local Sier-Bath Pump Representative or send for Bulletin G-3. *Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Blvd., North Bergen, N. J.*

Sier-Bath ROTARY PUMPS

Screw Pumps | Gearex® Pumps | Hydrex® Pumps

Founded 1905 | Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings | Member A. G. M. A.

New Equipment . . .

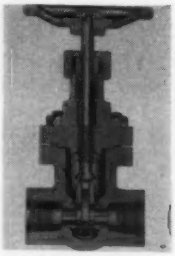


motor-driven balancing unit. There is, therefore, ample torque available for auxiliary functions such as retransmitting slidewires and alarm contacts. The Bristol Co.

Circle E22 on green card, last page

Small Steel Gate Valve In Bolted Bonnet Design

An inside-screw, small steel gate valve, newly designed and compactly made, has screwed or socket ends, available in a bolted bonnet design in 1½ and 2-inch sizes, and in a union bonnet in sizes ¼ through 1 inch. An inside-screw rising stem, solid-wedge disc, and rolled-in seat rings are features of the valve. Valves are rated 800 pounds at 850° F and 2,000 pounds at 100° F.



An accurately-machined solid-wedge disc is guided to a firm, tight seat without dragging across the seat rings. Disc is 13 Chrome stainless steel, heat treated completely through to eliminate chipping or cracking. Rolled-in 13 Chrome stainless steel seat rings never loosen in service and prevent leakage.

Deep and well-packed stuffing boxes assure long intervals before repacking is needed. Carefully machined back seats permit repacking under pressure when the valve is wide open.

Literature and other detailed information are available. Lunkenheimer Co.

Circle E23 on green card, last page

Bulletin Covers Cleaning Of Refining Equipment

"New refinery processing units often require derusting, descaling and cleaning before being placed on stream. Unless mill scale, rust and light oil deposits are removed, there is the risk of contamination and subsequent loss of product, as well as the danger of abrasion to costly accessory parts," states an up-dated service bulletin entitled "The Cleaning and Pickling of New Petroleum Processing Equipment."

A detailed, nine-step typical procedure for pickling of extractor circuits is featured in the bulletin along with a discussion of in-place circulation cleaning of towers, exchangers and related equipment. Oakite Products, Inc.

Circle E24 on green card, last page

Pump Details Covered In Technical Bulletin

Information frequently requested by engineers such as bearing life expectancy, shaft deflection, interchangeability charts and diagrams as well as the usual complete performance, application and dimension data is included in the revised bulletin describing a new line of chemical process pumps recently introduced.

The horizontal, end-suction, single-stage, centrifugal pump line is built in 11 sizes covering the range of 5 to 775 gpm, 10-300 feet tdh and are normally stocked in ductile iron, 316 stainless steel and Gould-A-Loy 20 to give quick shipment on units required for piping a wide variety of corrosive liquids at temperatures from —350 to +500° F. A high degree of interchangeability between pumps and parts, back-pull-out design and cooling jackets for bearings and stuffing box are outstanding features. Goulds Pumps, Inc.

Circle E25 on green card, last page

For Uniform QUALITY

Specify CHICAGO-WILCOX GASKETS

RING GASKETS

For ring-type flanged joints in high-pressure lines. Made of soft iron, standard steel alloys or any non-ferrous metal to any desired cross section. **Ask for Bulletin 563.**

HEAT EXCHANGER GASKETS

Made in any size or shape needed in double-jacket type. Also cut from solid metal or sheet packing. **Ask for Bulletin 564.**

CORRUGATED METAL GASKETS

Plain or jacketed type. Made of ingot iron, aluminum, stainless steel, copper, brass, nickel and monel in all sizes and shapes. **Ask for Bulletin 565.**

Write for Literature and Discounts — **Prompt Deliveries**

CHICAGO-WILCOX Mfg. Co.

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REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.

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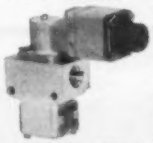
measurement and control

of pressure and differential pressure

NEW DESIGNS • NEW ACCURACY

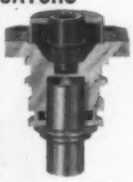
DELTADYNE® SWITCHES

Pat. No. 2,942,572



Adjustable for signalling pressure and differential pressure from 0.25" wc to 200 psi (or psid) in systems to 5000 psi and −65° to +275°F; leakproof. Units sound alarm, light bulb, turn motor on or off, operate valves — remotely or in place. $40 to $75

DELTADYNE INDICATORS



Adjustable and non-adjustable. Actuation 0.01 to 100 psi (or psid). For same pressure/temperature as switches. Red button pops to give visual indication of overpressure. $22 to $85

DELTADYNE GAUGES

For system pressures to 3000 psi; indication from 0 to 60 psi differential; leakproof — no moving seals; high-visibility scale. 0 to 60 psid, 3000 psi w.p. model. $92

TRANSMITTERS Complete with remote or in-place recorder.

Extended pressure and temperature ranges available in all instruments.

OFF-THE-SHELF OR CUSTOM-ENGINEERED FOR

- **Hydraulic/pneumatic systems (airborne, ground support, industrial)**
- **Process industries (chemical, petroleum, fuels)**
- **Equipment manufacturers (fluid handling)**

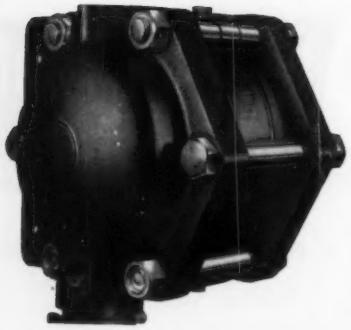
Read or control tank levels, and pressure drops across filters, heat exchangers, orifices for flow metering, gas adsorbers and many other types of equipment. Learn more about the cost and service advantages of these units.

WRITE FOR COMPLETE LITERATURE

PALL

PALL CORPORATION

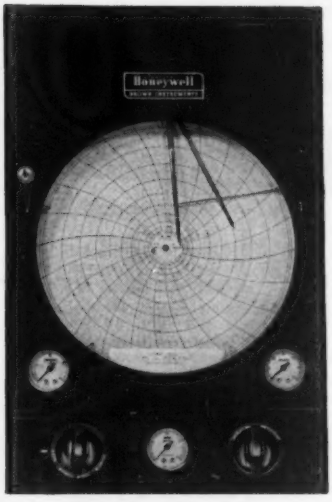
GLEN COVE, NEW YORK



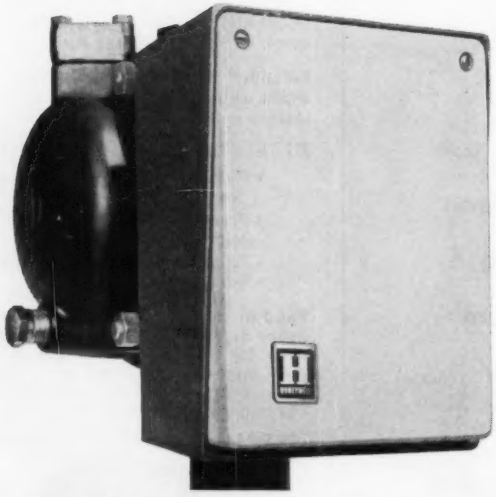
Honeywell Bellows Meter brings

Six of many ways you can use the bellows meter

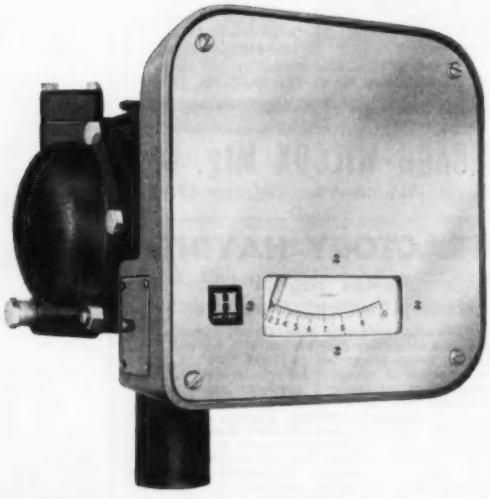
As a Recorder or Integrator—Recorders can have one, two or three pens, with the second and third pens actuated by thermometer or pressure elements. A single-pen recorder is shown above. You can get integration, too.
Write for Specification S 292-2a.



As Recording Controllers—You can get recorders with pneumatic ON-OFF, 10% *Throttlor*, 150% *Throttlor* with manual reset, or *Air-O-Line* (150% proportional band-plus-automatic reset) control. A single-pen pneumatic controller with integral bypass is shown above.
Write for Specification S 292-2a.



As a Non-indicating Pneumatic Transmitter—Use this non-indicating transmitter when you don't need indication at the point of measurement, and when the measured variable is to be transmitted to remotely located instruments.
Write for Specification S 230-1.



As an Electric Transmitter—You can use this *ElectriK Tel-O-Set* electric flow and liquid level transmitter with indicators, recorders, and controllers, with data handling systems, or with millivolt receivers. Field indication, as shown, is optionally available.
Write for Specification FS 301-7.

new versatility to flow or liquid level measurement

As an Indicating Pneumatic Transmitter—Gives you indication at the point of measurement, plus pneumatic transmission. Easy-to-read scale, and large indicating pointer. Case is only 4 by 7 by 9 inches.
Write for Specification S 230-1.

As a Dial Indicator—Six-inch dial indicator gives easy, accurate readings at point of measurement. This meter-indicator is designed specifically for field indication.
Write for Specification S 224-1.

You can use the Honeywell Bellows Flow Meter as a recorder, controller, indicator or transmitter . . . pneumatic or electric. Use it for accurate, low-maintenance metering of flow—for steam, water, gas, oil or other fluids—or for liquid level measurement. In all of its many forms, with all of its performance advantages and operating economy, it is the most advanced flow and liquid level meter available today.

Some outstanding features:

Stability—The meter body will operate over an ambient temperature range of —40° to 250°F. Over a range from —32° to 150°F. the accuracy will not change more than 0.5%.

Leakproof construction—Hydraulically formed stainless steel bellows eliminate any chance of leakage between fill and process fluid.

Quick, easy damping—Rectangular orifice pulsation check varies the speed of response over a ratio of 20 to 1. Adjustment is essentially linear and can be made from outside the meter body while the instrument is operating.

Sensitivity and accuracy are well within the required limits of measurement and control on applications for which these instruments were designed.

Convenience—Change range easily in the field by replacing a single range spring assembly. The meter body is self-venting when measuring liquids and installed below the flow line; self-draining when measuring gas and installed above the flow line.

There are models of the Honeywell Bellows Flow Meter available in many ranges, for every application. Your nearby Honeywell field engineer can give you complete details and help you select the correct model for your application. Call him today.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

H HONEYWELL *First in Control* SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Clear sparkling waters don't fool corrosion engineers

Coupled with temperature, pressure and velocity, some waters can chew up condenser tubes faster than you would believe possible. Minute differences in oxygen, chemical or biological content give each a corrosive character of its own that calls for well-informed tube alloy selection.

Case histories in which tube life has been increased from months to *years*—or from years to many *more* years—are packed in Bridgeport's files. The training and experience of our corrosion specialists can help match the best tube alloy to your water supply—whether potable, saline, brackish or polluted.

Write for information on Bridgeport's regular or Duplex tubes—or call in a Bridgeport man for quick and practical assistance on your corrosion, erosion or bio-fouling problems.

Bridgeport condenser and heat exchanger tubes in over 50 metals and alloys:

INHIBITED ADMIRALTY
INHIBITED ALUMINUM BRASS
INHIBITED MUNTZ METAL
70-30 CUPRO NICKEL
90-10 CUPRO NICKEL
DEOXIDIZED ARSENICAL COPPER
INHIBITED ALUMINUM BRONZE
RED BRASS
ALLOY 77 MERCURY BRASS

...plus **DUPLEX TUBES**...in combinations of the above alloys, with carbon or stainless steel, aluminum, Monel,® nickel...or other metals.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut

Bridgeport

"We need valves for rugged, continuous operation."

"We need valves that will reduce maintenance and replacement costs."

"We need valves for our severe high temperature-pressure applications."

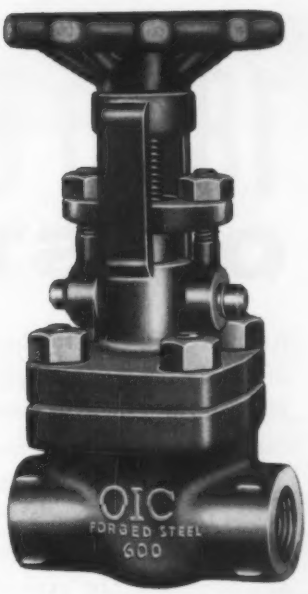
The answer to all 3 is OIC

FORGED STEEL VALVES

Key men . . . responsible for maintaining continuous production with minimum downtime . . . know the importance of valve performance!

That's why OIC, with years of experience in the chemical and petroleum industries, developed a complete line of forged steel valves for rugged service in high temperature-pressure applications.

Available for operation on all lines up to 2-inches, OIC forged steel valves are designed to meet your control requirements with minimum replacement and maintenance cost. Consult your local OIC distributor today. He can help you select the exact valve you need.



Available with trims to service most applications, and with socket weld, flange and screwed end connections.

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FOR TITAN MISSILE BASES...

1800 EXPANSION JOINTS OF STAINLESS STEEL

Air Force Titan missile bases require many miles of stainless steel LOX piping. To protect these piping complexes from thermal changes and shock conditions, special stainless steel expansion joints —1800 of them—were required.

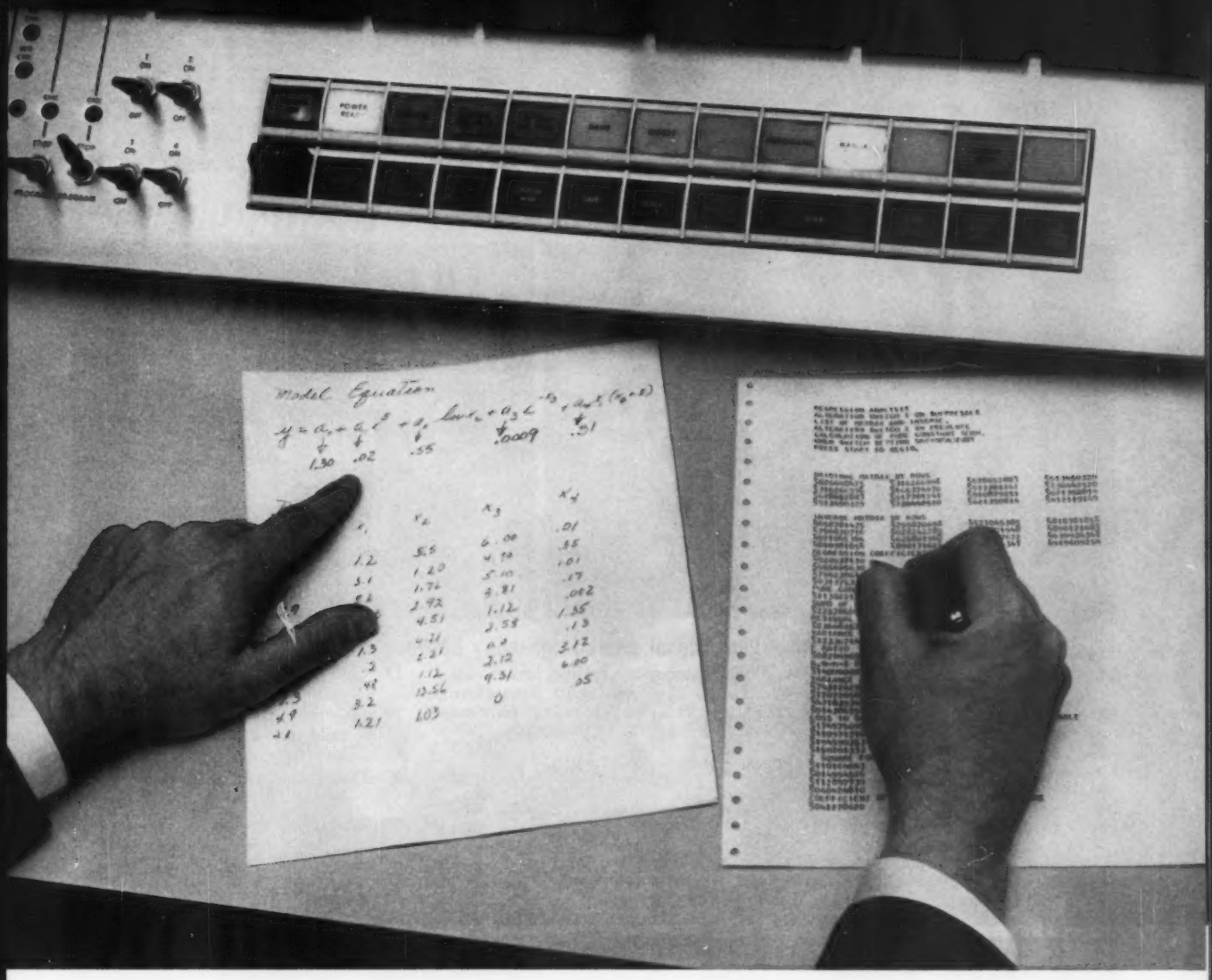
Adsco built these special expansion joints, taking them carefully through design, forming, welding, and assembly. The expansion joints were cycle-tested with liquid nitrogen at -297° F. and cleaned. The Corps of Engineers inspected each one under black light and each joint was hermetically-sealed. System cleanliness limits were 25 parts per million —150 micron particles.

Knowledge and experience such as this could be of help to you in your expansion joint work. Call on Adsco!

ADSCO DIVISION
20 MILBURN STREET
BUFFALO 12, NEW YORK

YUBA

YUBA CONSOLIDATED INDUSTRIES, INC.



Want to find the coefficients? It's easy with the new Regression Analysis program for the IBM 1620

Here's another program offered free-of-charge to users of the IBM 1620 Data Processing System. It gives you the kind of results you might expect only from a much more expensive computer. But users of the 1620 know that its low rental cost is deceptive. The 1620 packs *more computing power per cubic inch* than any other computer in its size range.

The Regression Analysis program is a good example. Suppose you want a fit for production purposes. If you employ more than two variables you probably have difficulty visualizing the representation of your data. If linearity is not the case, you must often guess blindly at a polynomial of high degree, accept or reject the fit with something approaching a sixth sense, and either try again or settle for the results you have.

The new Regression Analysis program lets you handle expressions containing up to *24 variables*. If you have the even more complicated task of handling many dependent variables, the program will generate regression coefficients with a maximum number of dependent variables not exceeding one-half the number of independent variables.

This program will also fit non-linear functions and hyper-surfaces. Compare this performance with that of any other computer in the 1620's price range.

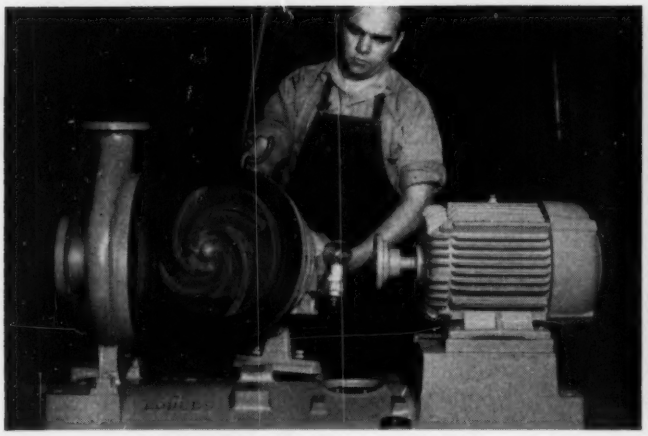
A basic 1620 installation rents for just $1600 per month. For details, contact your local IBM Representative.

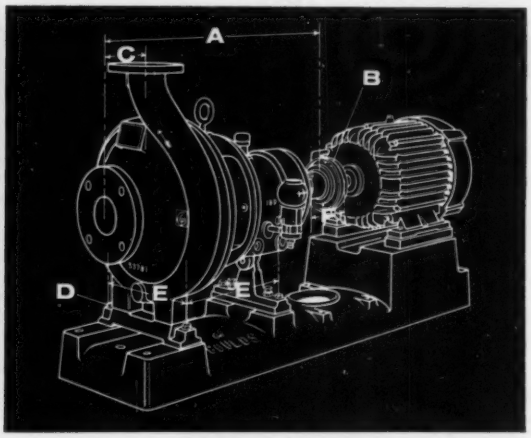
IBM's 1620 is a compact desk-size computer.

IBM®
DATA PROCESSING

PUMPAGE

Goulds news about pumps for process industries





Standardized design features

Model 3195 gives you the greatest range of coverage and flexibility—with minimum parts needed—of any design on the market.

To meet varying service conditions, you can mount any one of the 11 pump ends to any one of three bearing frames (shafts 1¼, 1¾, and 2⅛ through stuffing box). Nominal impeller diameters of 6″, 8″, and 11″ cover the range. Capacities to 775 G.P.H., heads to 300 ft. TDH. Handles liquids up to 500°F.

Dimensional interchangeability between all Model 3195 pumps

With this top-centerline, broad-coverage design, you can interchange pumps without making expensive piping changes. It has

A	One over-all length in all sizes	23″
B	One coupling fit for all sizes	1⅛″
C	One dimension end from suction to centerline of discharge	4″
D	One bolt size for holding pumps to bases	½″
E	One bolt spacing for holding all pumps to bases	
F	One spacer coupling length for all sizes	3½″

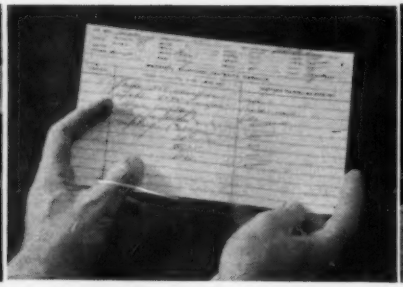
Back pull-out design lets you easily replace parts most subject to wear without disturbing pipe connections or motor mountings. For full information, write for Bulletin 725.1.

How to dewater a flood

Deep in a Virginia mine, water that could fast become a flood is being pumped out at as much as 8000 gpm for New Jersey Zinc Company.

More than a generation of miners has grown up since the first of the pumps started working. Yet these pumps, as well as the newer ones, perform so dependably that four more are slated to join them.

All 30 are Goulds single-stage, double-suction centrifugals. All use mechanical seals. All are grease lubricated.

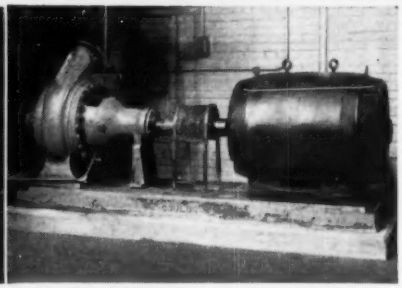


Easy way to diagnose pump failure

Keep complete maintenance records on easy-to-use cards. Failures show chronologically, making it easier to get at the root of the trouble.

Cards are a help in ordering new parts, scheduling lubrication, and in determining pump suitability for new requirements due to process change.

Like a free supply of these pump maintenance record cards? Drop us a line. For information on this, or other products on this page, write Goulds Pumps, Inc., Dept. PR-91, Seneca Falls, N.Y.



Unique-alloy pump fights abrasives

The first pump in the system at Bestwall Gypsum Company's Pryor Mill works on a particularly tough service. It must handle bits of metal and glass the junk remover doesn't get.

It's a Goulds Model 3139 constructed of ISO-40.* This stainless steel alloy, highly resistant to corrosion and abrasion, has BHN hardness of 320 and tensile strength of 140,000 psi.

Do you have a similar severe application problem? Let us know. ISO-40 is available in several of our designs.

*Registered trademark of Empire Steel Castings, Inc.

GOULDS PUMPS

A NEW ADDITION TO THE SONAC *LINE*

POSITIVE ULTRASONIC LEVEL CONTROL

The components of Sonac (sensor actual Size)

Now, two new ultrasonic sensors, especially for level control have been added to the Delavan line of SONAC sensing and switching devices.

The single sensor system is recommended for liquid level control and the double sensor system for dry level control.

Control is maintained by installing the SONAC sensor through the wall of the vat, bin or hopper. When the oscillation on the face of the sensor is dampened or impeded by the material being sensed, the signal to the control unit changes, activating a relay.

FIG. 1—LIQUID LEVEL (One Sensor)

FIG. 2—DRY LEVEL (Two Sensors)

For level control, SONAC is accurate to .005" and has a response time of 25 milliseconds. Performance of the sensor does not deteriorate with age.

The level control uses to which SONAC can be applied are virtually unlimited. It is not affected by the viscosity*, specific gravity, conductivity, or capacitance of the material being sensed. Temperature or pressure changes of the material do not alter its performance. False signals are eliminated because SONAC may be adjusted so as not to sense steam, foam, or vapors.

*Viscosity may affect response time.

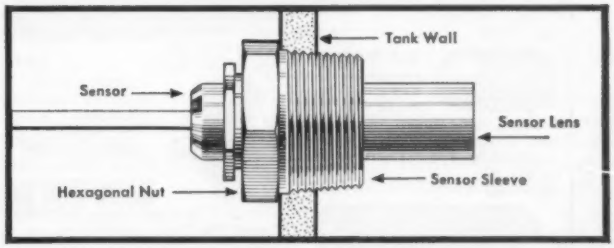
Canadian Representative:

KNOWLES & FOSTER (North America) Ltd.

708 Terminal Bldg., Toronto 1, Ontario, Canada

SONAC is extremely rugged. Sensors are type 304 stainless steel. The electronic components in the sensors are hermetically sealed and will withstand pressures to 2000 psi and temperatures from −425° F. to +450° F. They are immune to shock, vibration or mechanical damage.

The control is a compact unit 5" x 5" x 5" and features transistor circuitry. Power consumption is one watt and the unit will operate in temperature ranges from 40° F. to 135° F.



The compact single SONAC sensor usually is inserted through the tank wall, as indicated in the above drawing. It can be arranged in other ways, too.

There are dozens of applications for SONAC *single and double sensor units. Let it go to work for you now, write:*

DELAVAN
Manufacturing Company
WEST DES MOINES • IOWA

If you use stainless steel plate, this new booklet on Carlson services in stainless steel gives you worthwhile facts!

THIS new Carlson booklet, "Producing Stainless Steels . . . Exclusively," documents a unique, specialized service. Fully illustrated, it includes detailed sections on stainless steel plates, heads, forgings, special shapes, and other stainless products manufactured by Carlson.

Write for your free copy of the new Carlson booklet today.

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Leashes For Glassware

NON-RUST—STAINLESS STEEL SPRING

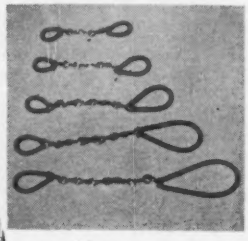
Available in five sizes: Extra Small, Small, Medium, Large and Extra Large. In addition we furnish Assorted Sizes in envelopes of one dozen, consisting of two Extra Small; two Small; four Medium; three Large and one Extra Large.

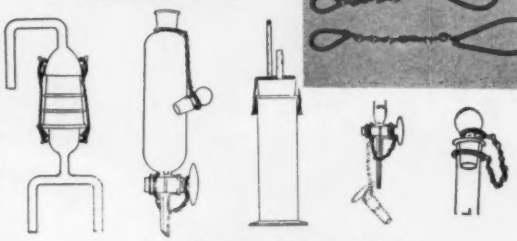
How To Use Leashes: Simply slip the small spring loop over the top of stopper or stopcock plug while the large loop is slipped over the stopcock shell or the neck of bottle, flask, cylinder, etc.

To Save Glassware: Apply Leashes to all newly received glassware shipments. Use, clean, and drain-dry your glassware without removing Leashes. This keeps your expensive glassware parts together.

Envelopes of one dozen

Leashes, Extra Small, DS 120ES
" Small, DS 120S
" Medium, DS 120M
" Large, DS 120L
" Extra Large, DS 120EL
" Assorted (as above)





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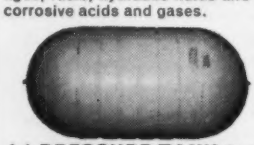
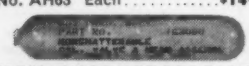
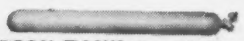


J-1 PRESSURE TANK Stainless steel, surplus aircraft oxygen tank. 48" long, 24" dia. Rated for 400 P.S.I. working pressure, 18,000 cu. in. vol., 77.9 gal. capacity. ¼" pipe thread fitting at each end. New condition. Shipping weight 247 lbs. F.O.B. Chicago.
No. AH832 ..... $99.50

G-1 TANK Stainless steel. Capacity 2100 cu. in. (9 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 12" dia. Shipping weight 19 lbs. F.O.B. Chicago. (Two for $27.00.)
No. AH63 Each $14.95



NON-SHATTERABLE CO_2 CYLINDER This type of pressure bottle was used by the Armed Forces for inflating life rafts. 18¼" long, 3¾" dia. Has ½" pipe thread opening at one end. Capacity 2.98 lbs. of CO_2—at 1800 P.S.I. Shipping weight 10 lbs. F.O.B. Chicago.
No. AH303 ..... $2.50



FREON TANK Capacity 22 oz. of Freon F22, 6 cc Methyl Alcohol. 18¼" long, 2" dia. ⅜" pipe thread opening at one end. Equipped with brass valve. Shipping weight 3 lbs. F.O.B. Chicago. (Six for $8.00).
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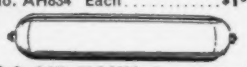

D-2 AIR TANK Carbon steel. Capacity 500 cu. in. (approx. 2 gals.) 450 P.S.I. ¼" pipe thread port at each end. 24" long, 6" dia. Postpaid. (Two for $8.50).
No. AH391 Each $4.95

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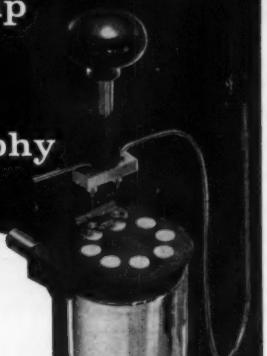

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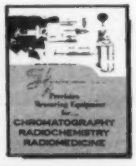

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On process stills or boilers—or wherever large volumes of heat are involved—Ljungstrom Air Preheaters improve combustion, make fuel burn more completely. It's possible to save as much as 20% on fuel. ***All* major public utilities** use Ljungstroms; as do many major chemical and petroleum processing companies. Chances are, you, too, could benefit. For additional information, call or write The Air Preheater Corporation, specifying type of application.

THE AIR PREHEATER CORPORATION

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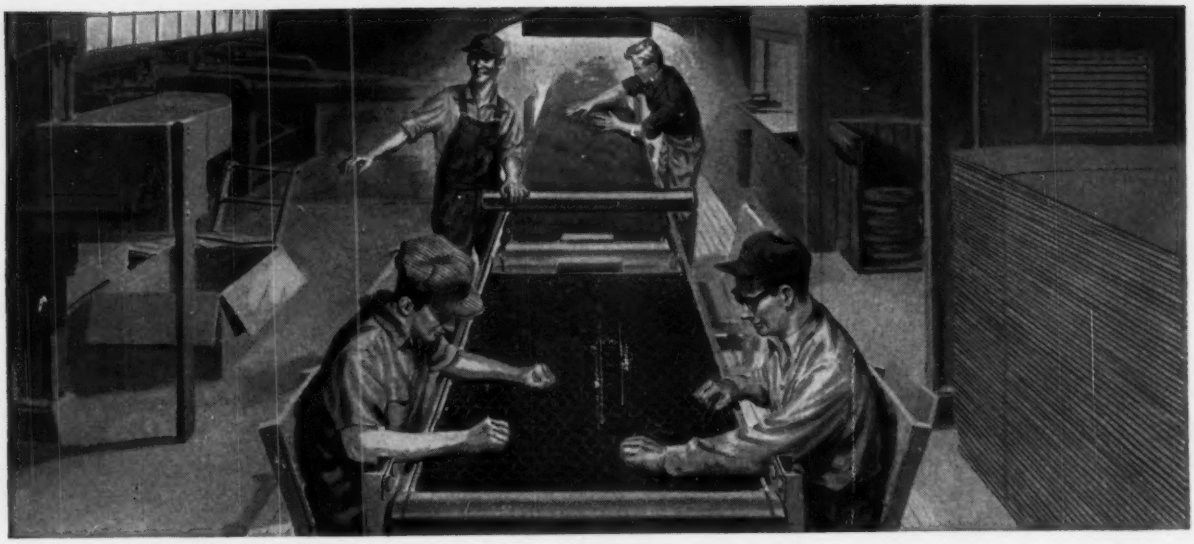

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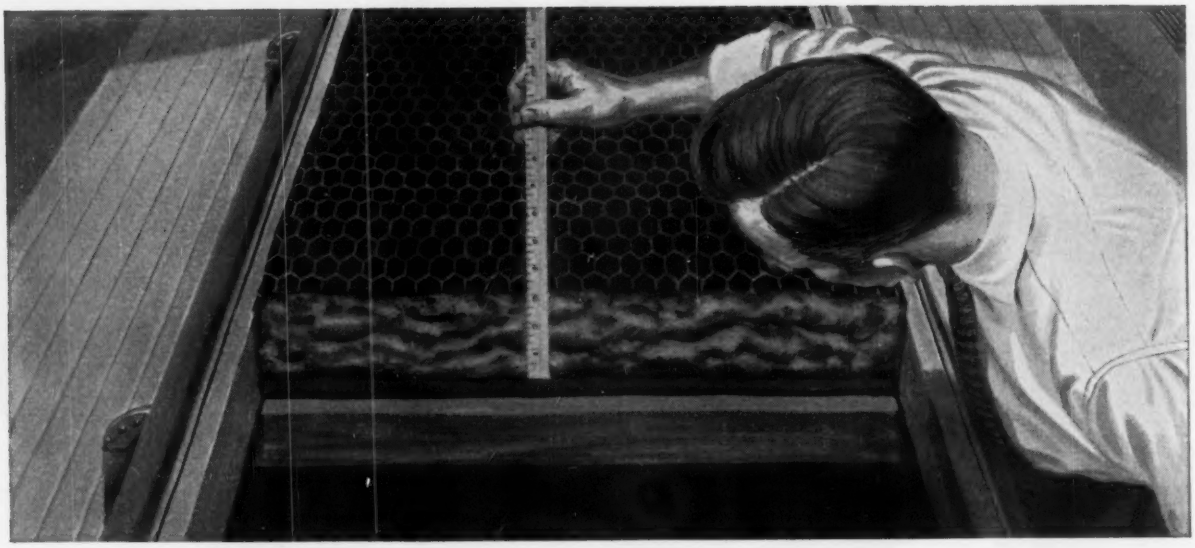

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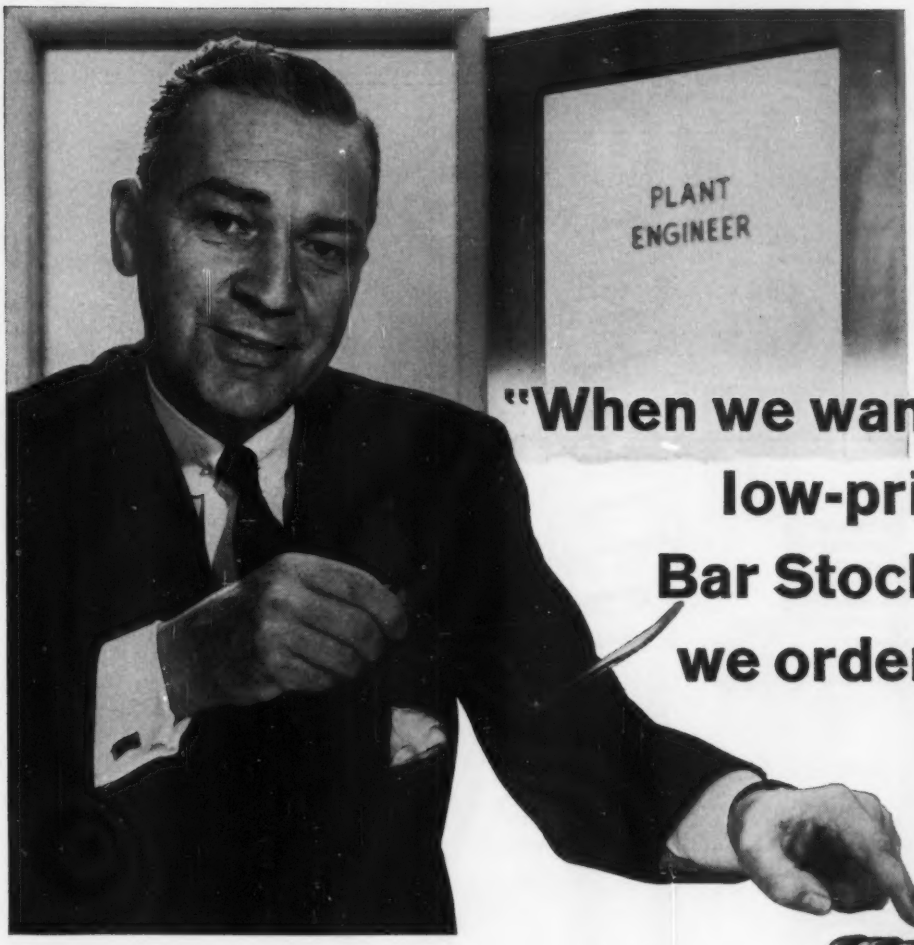

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"For a really versatile, **all-purpose** valve, we've found there's none better than R-P&C bar stock valves. Designed and built **for close control service,** the construction of these valves makes them well suited to many general purpose applications as well. For example, the **compactness** of R-P&C bar stock valves is particularly advantageous for close-coupled installations in instrument lines or on panel boards and for pressures up to 10,000 lbs. in steel."

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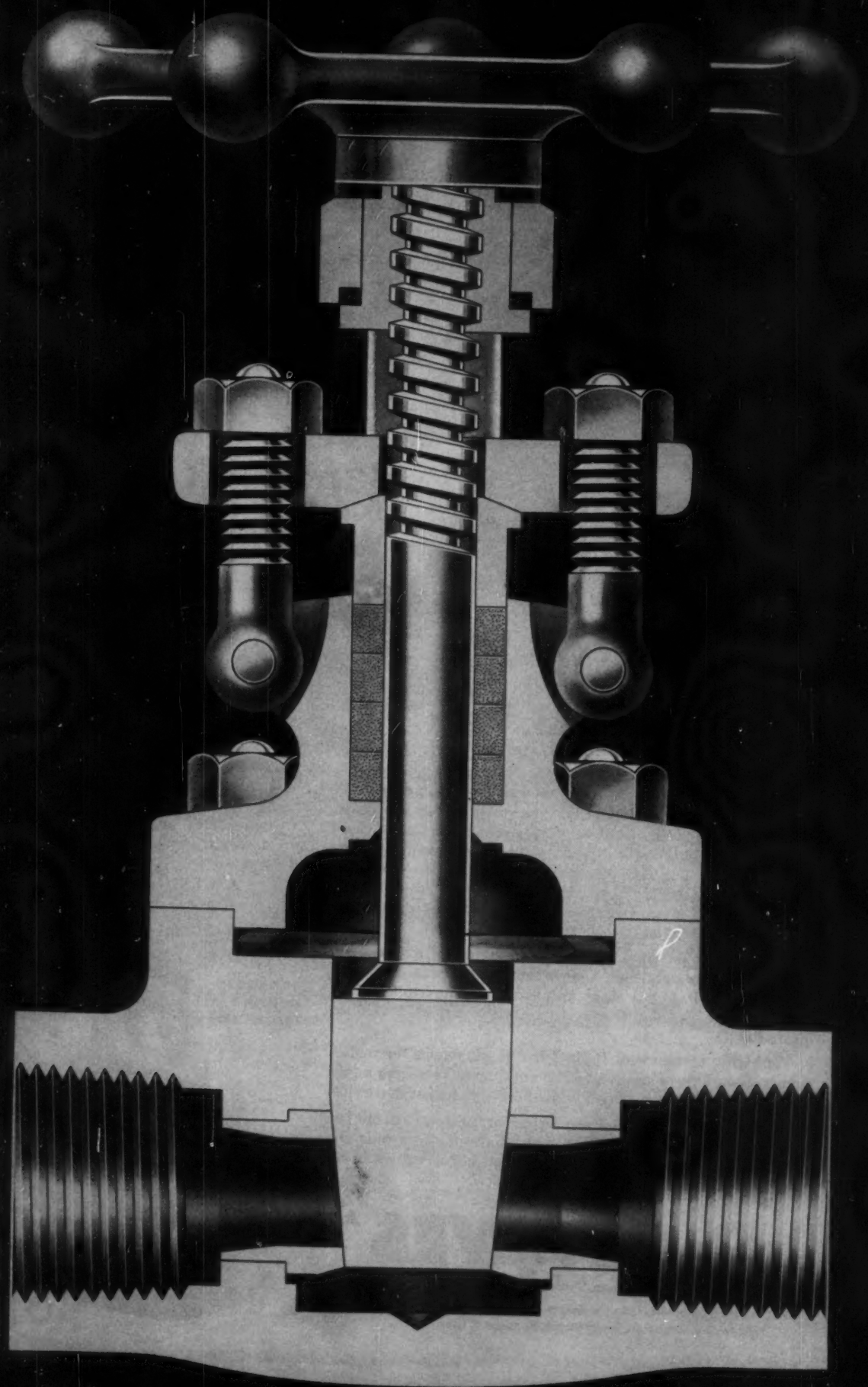

The reputation of a valve is made by the plants it keeps on stream

A valve is often looked upon as a "supply item" until it prevents a major process shutdown and profit loss...

Hancock Steel Valves provide the dependable protection demanded for every process application today and tomorrow. They are available in a wide range of operational pressures and temperatures . . . in an extensive selection of alternate trim, body, and bonnet materials to match the toughest services. They have that extra measure of quality that only a leader knows how to build into a valve...extra quality that extends the operating period between turnarounds and assures efficient, economical processing of petroleum and chemical products.

The valve illustrated at the left is the Hancock Type 950 Steel Gate Valve widely used by the processing and power industries.

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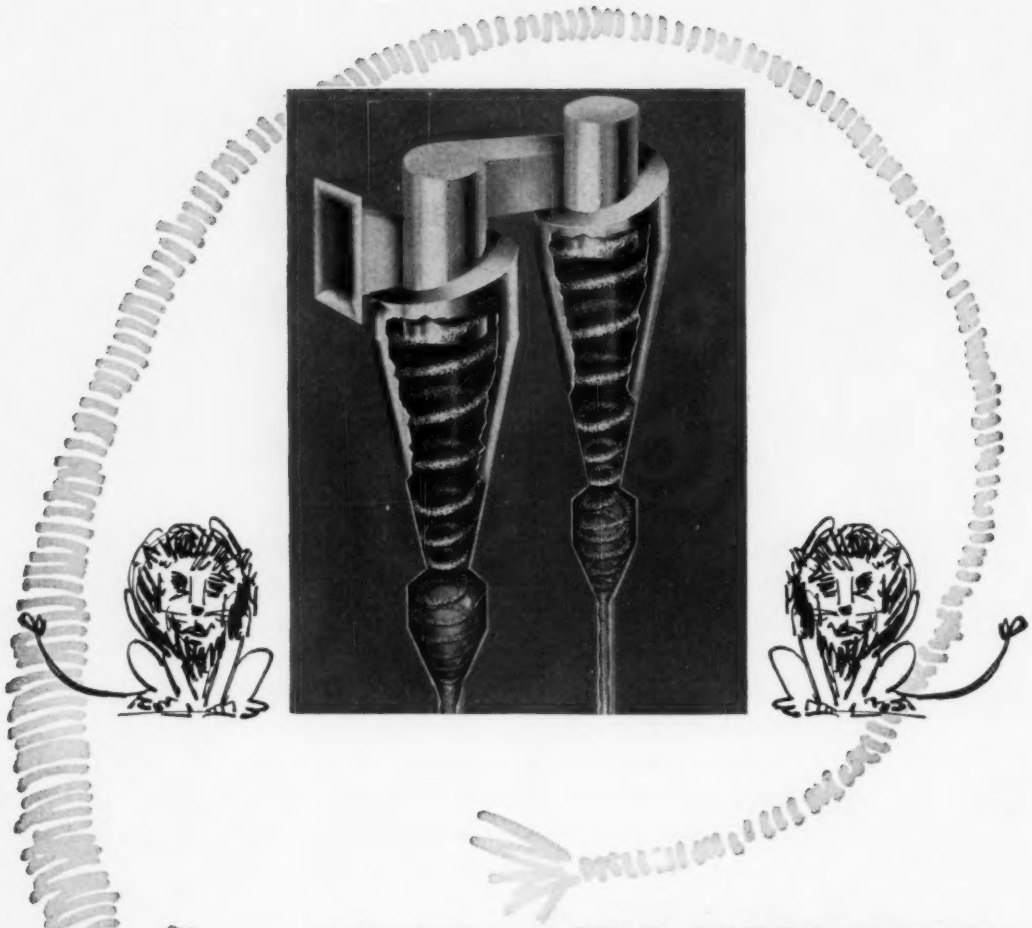

WE KEEP THE "BIG CATS" CRACKING

The "Big Cats," those steel behemoths that work wonders with the gasoline molecule, have a wild streak in them. Unless kept under control they can whip up a storm of flying catalyst dust that raises havoc with the operation and brings the Air Pollution Control people running.

To avoid this embarrassing and economically hazardous situation, refiners install our high efficiency SDC Duclones and Trickle Valves. They save money . . . improve performance . . . and in general do an admirable job. They snare each flying catalyst particle and plummet it back into the fluid bed to perform the miraculous task of catalytic cracking.

Is it any wonder that Duclones were used in two large refineries which set records for continuous on-stream service.

For more information on how SDC Duclones can keep "Big Cats" cracking, send for bulletin C-2058.

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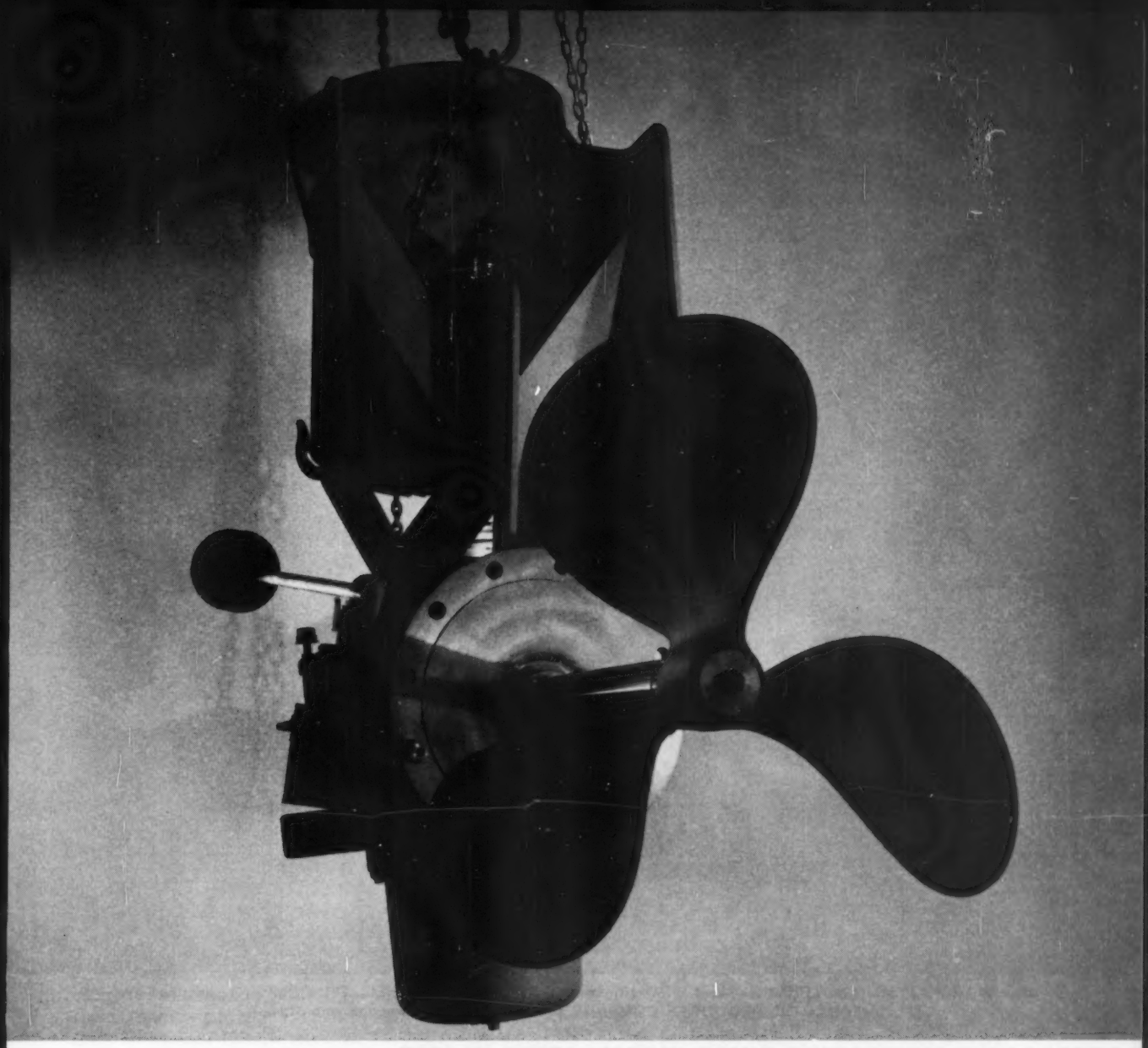

Now—blend big tanks with less installed power

This side-entering mixer will deliver up to 50% more fluid flow than any other mixer of the same size.

It's one of the new series of LIGHTNIN Mixers—a Hi-Flo line especially designed to handle the big jobs economically.

These new mixers give you extra pumping capacity. More usable *blending power* for every unit of power input. You save on power load, on hookup, on installation costs . . . yet you get the same—*or better*—blending results.

For example: one LIGHTNIN 40 hp unit will do the job of three conventional 20 hp mixers. A LIGHTNIN 20 hp unit will do more than the conventional 25 hp mixer. In most cases you can use a 15 hp LIGHTNIN unit where previously you've required 25 hp. The savings in initial cost, installation and operation really mount up.

Get details now. You get economy and performance like this only with the new LIGHTNIN Side Entering Mixers. The hollow-quill NSE series with independent shaft support; the brand-new RSE series with the mixer shaft directly connected to the speed reducer; and the V-belt-driven VSE series.

For details, just call your LIGHTNIN Mixer representative. He's listed in Refinery Catalog and in the yellow pages of your telephone book. Or write directly to us. Ask for Bulletin B-526.

Send me your Bulletin B-526 describing the new line of side-entering mixers. (For prompt attention, clip and mail this coupon with your name, title, company address.)

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MIXCO fluid mixing specialists

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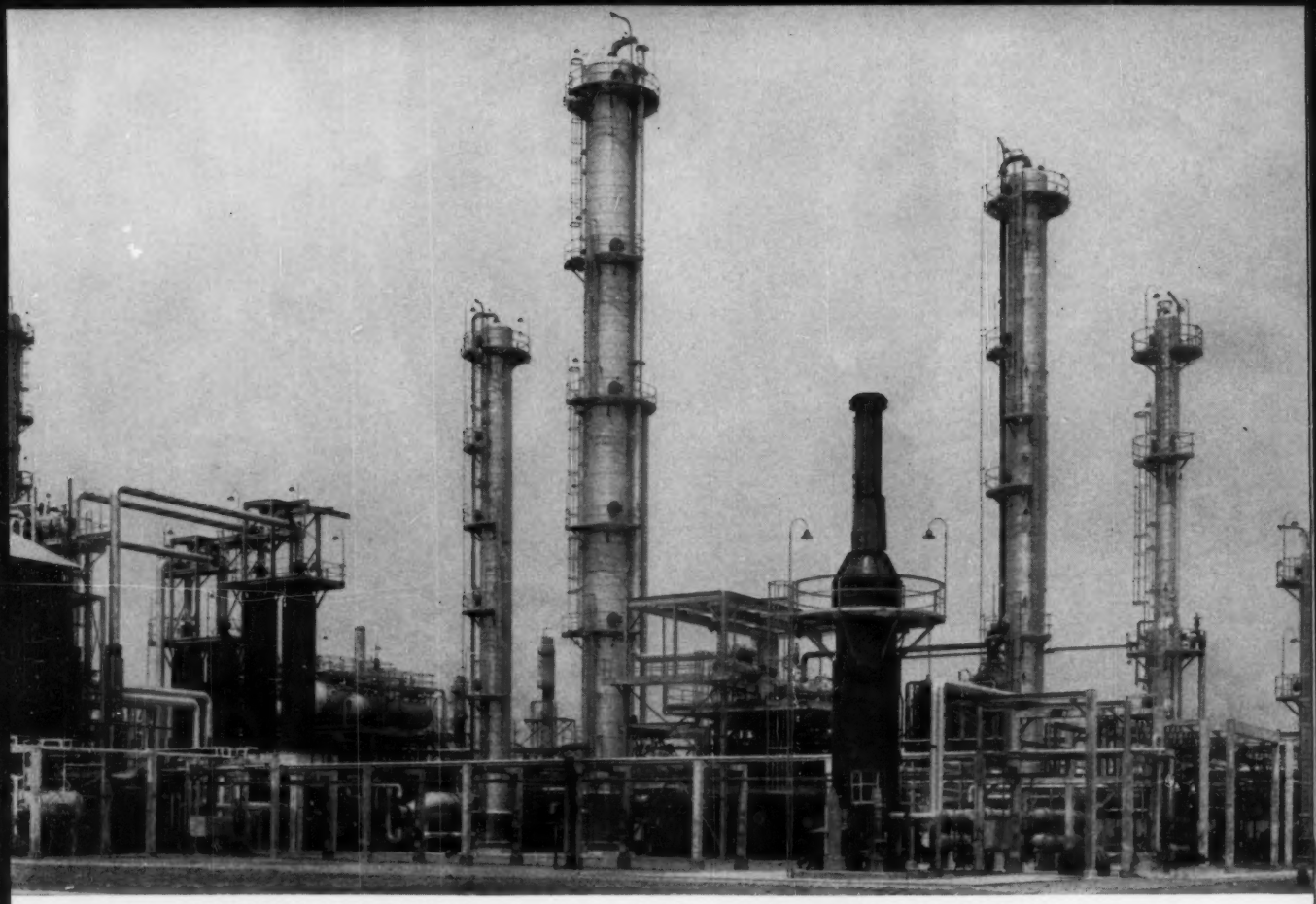
CHOSEN BY UOP AND SHELL



View of 16,000 BPSD PLATFORMING® unit at the Houston, Texas, Refinery of SHELL OIL COMPANY, licensed by UNIVERSAL OIL PRODUCTS COMPANY and designed in conjunction with Shell.

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The Platforming® process enables a refiner to make a larger percentage of top quality gasoline and petrochemical intermediates.

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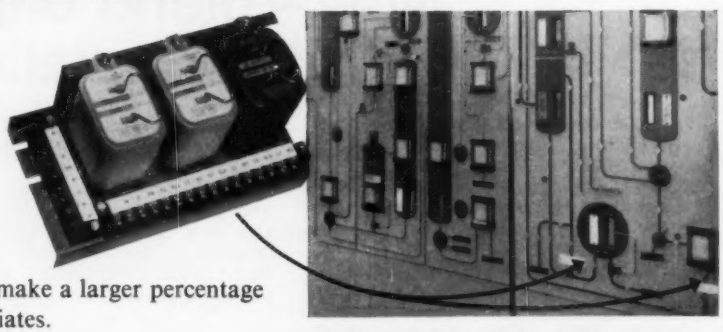

Panalarm Annunciators warn Platformer T.M. operators when undesirable conditions develop at critical points by illuminating appropriate translucent plates on this graphic control panel, only a portion of which is shown. When desired, a simultaneous audible signal also attracts attention.

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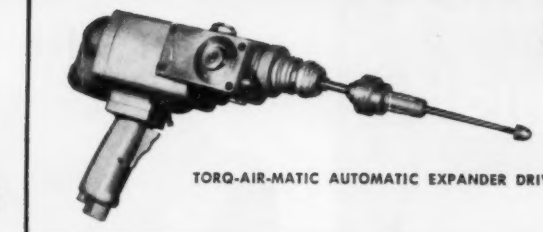
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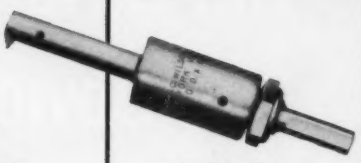
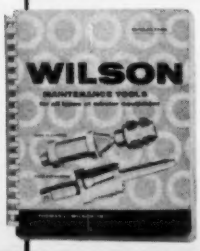

TUBE CUTTER

TUBE EXPANDERS

TUBE PILOT



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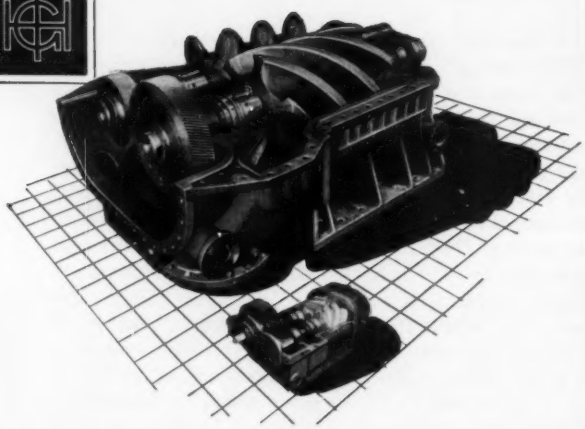

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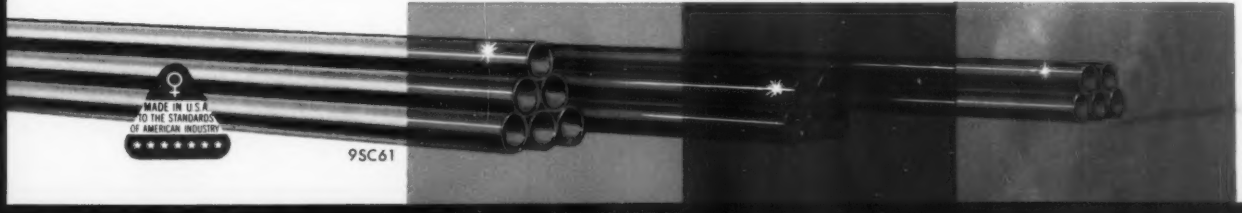

9SC61

Hawaii bids "Aloha" and a warm welcome to a new star in the Islands... Texaco. Shown here receiving a traditional greeting are the first of the Islands' new Texaco Dealers and their able assistants. Only Texaco, at the sign of the big red star with the green T, serves motorists in all 50 states of the U. S. A. Texaco, pioneer and one of the leading producers, refiners and marketers of petroleum, takes pride in serving Hawaii, and continuing its capital investments in the economies, the people and the progress of the Free World.

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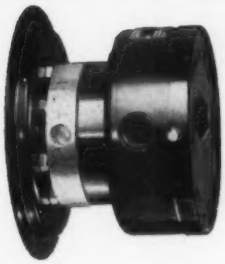
PRESSURE CONTROL OPERATES DOWN TO 1″ (wc) WITHSTANDS 600 PSI INDEFINITELY

This Mercoid low pressure control with operating range of 1"-60" (wc) assures accurate repetitive trip point for low pressure values with dependable over-pressure protection.



SUGGESTED APPLICATIONS:

- *Provide an electrical interlock on a high pressure autoclave, rubber moulding machine or pressurized vessel to prevent opening until the pressure drops to 1" (wc) and withstand operating pressures as high as 600 psi.*
- *A low pressure gas cut-off for a steam generator where normal gas pressure is up to 150 psi, but safe operation can be maintained down to ½ psi.*

Control can be furnished with special construction for use with corrosive gases. Case styles are available for indoor, outdoor or hazardous locations.

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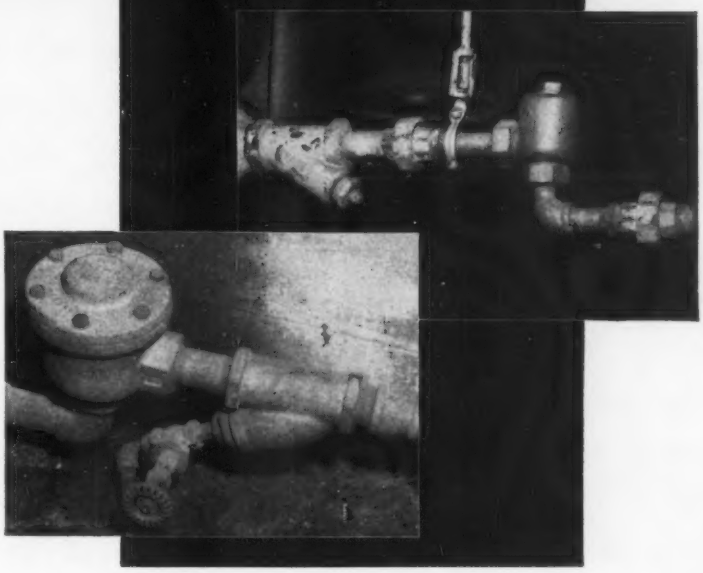
MERCOID CONTROL®

Consider These Facts about

THERMOSTATIC TRAPS

TO ASSURE HIGH EFFICIENCY AND LOW MAINTENANCE



Every trapping requirement cannot be met with one trap. Consequently Anderson manufactures a complete line of traps including the remarkable Quik-Flex Thermostatic Steam Trap. From one source you can meet all your trapping needs. If you are using or planning to use thermostatic traps, consider these important facts – features built into every Anderson Quik-Flex Trap.

- **Large capacity covering a wide pressure range simplifies specifications.**
- **Only one moving part assures low maintenance and less downtime.**
- **Fast heating up of units through quick discharge of condensate and/or air.**
- **Guaranteed freeze-proof when properly installed and operated for outdoor operation.**
- **Compact design permits simplified piping in hard-to-get-at places.**
- **Immediate delivery is guaranteed from inventory.**

Write FOR COMPLETE INFORMATION AND BULLETIN 257 DESCRIBING THE ANDERSON QUIK-FLEX THERMOSTATIC TRAP.

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5909 W. VINE STREET • HATFIELD, PA.

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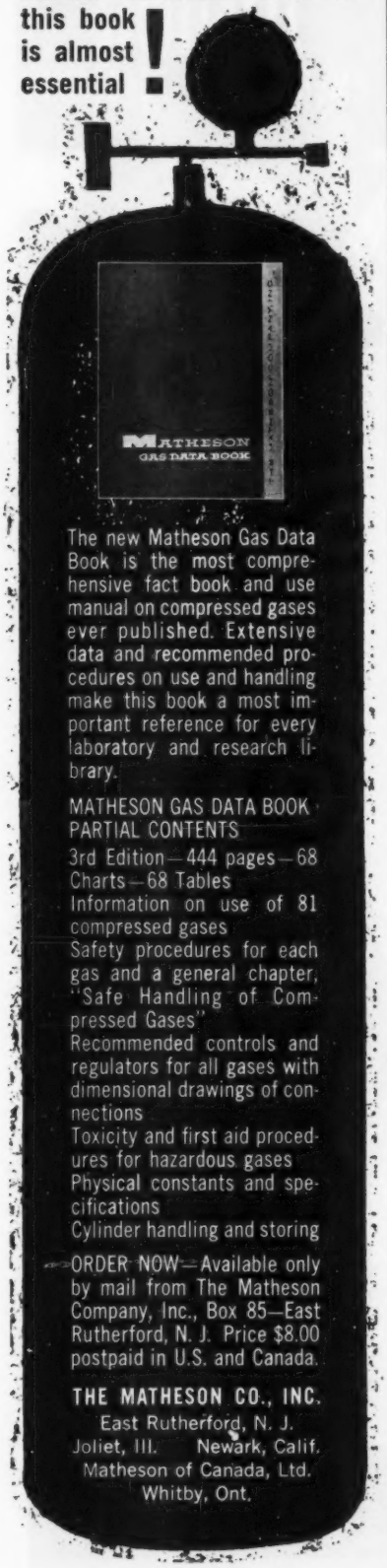
this book is almost essential !



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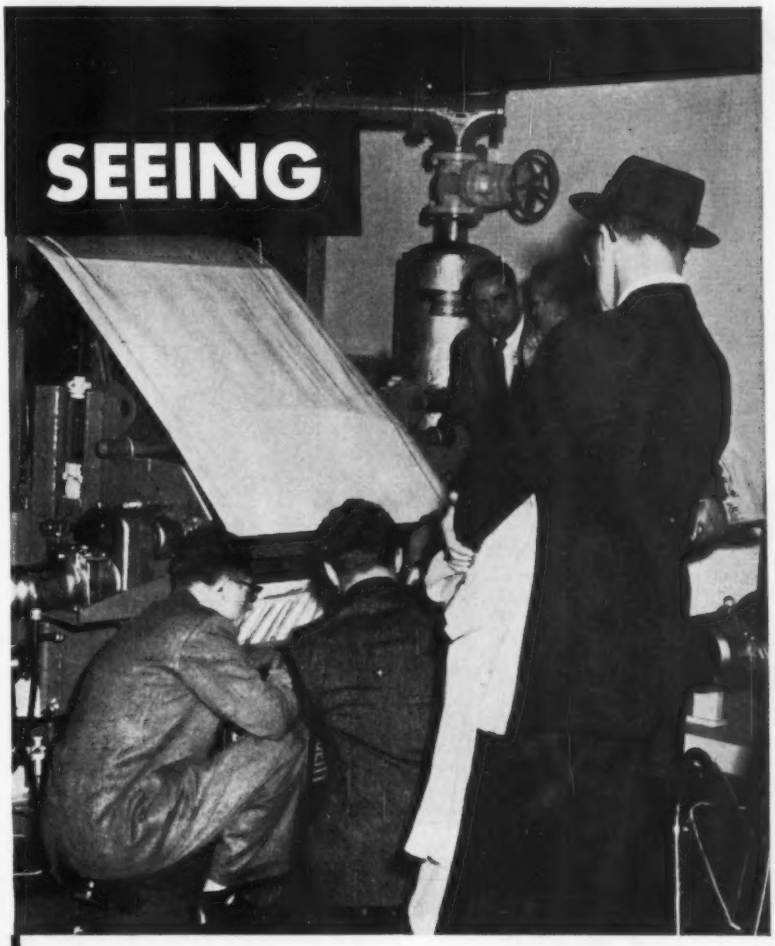

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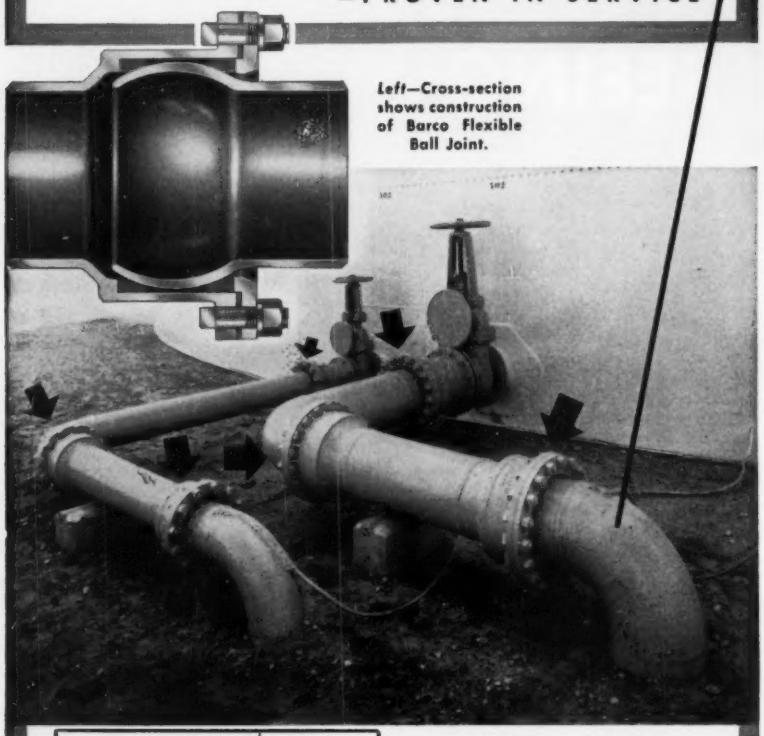
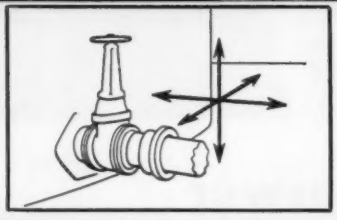


Left—Cross-section shows construction of Barco Flexible Ball Joint.



Allows 6-Way Movement!

Freedom of movement in any direction is readily possible with these *ball joint connections* of 12" pipe (right) and 8" pipe (left) to 80,203 bbl. tank shown in above photo. (Photo: SHELL OIL COMPANY, Dominguez Refinery, Wilmington, Calif.)

Barco Ball Joints—*Fire Safe!*

provide complete protection against FIRE, PIPE EXPANSION, TANK SETTLING

Major oil companies throughout the country now approve the use of Barco's new large size Flexible Ball Joints on tank connections for the following reasons:

1. Fire-safe. The joints have passed rigid fire and water spray tests.
2. Superior for handling pipe expansion—no combustible packing, no thin wall sections, no "end thrust" from pressure, no heavy pipe anchoring required.
3. Complete protection—relieve strain and twisting forces on valve flanges or tank wall.
4. Compact! Ideal for use inside narrow space between fire wall and tank. Easy to design piping for any amount of flexibility desired.
5. Also useful for insulating piping against electrolysis.
6. Long service life without maintenance. No lubrication. Sizes to 16"; flanged or welding ends.

For engineering recommendations, see your nearest Barco representative or write. ASK FOR CATALOG 215B and BULLETIN 31-A.

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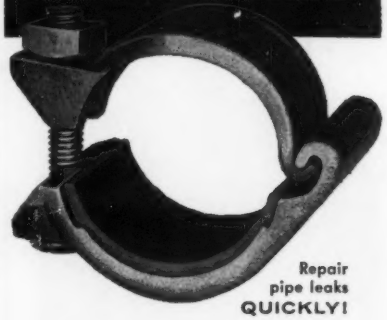
For Speediest Repair of Corrosion Leaks in Pipe

JUNIOR
EMERGENCY PIPE CLAMP

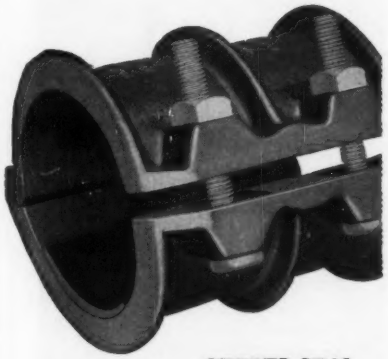


Repair pipe leaks QUICKLY!

Speediest application — slotted lug permits the single plated bolt to slide instantly into place.

A companion to the old reliable Emergency Pipe Clamp that has served industry for a half century, the JUNIOR, a single bolt clamp, is 2⅞" wide. Undersells most band-type clamps.

Made of malleable iron, ruggedly proportioned, with full-length hinge along one side. Formed to exact pipe size—no bending. The recessed pressure-equalizing gasket, entire width of clamp, is cemented in. A lasting installation. 2" pipe size—$1.80; 2½"—$2.20; 3"—$2.30. Write for new circular on the Junior.



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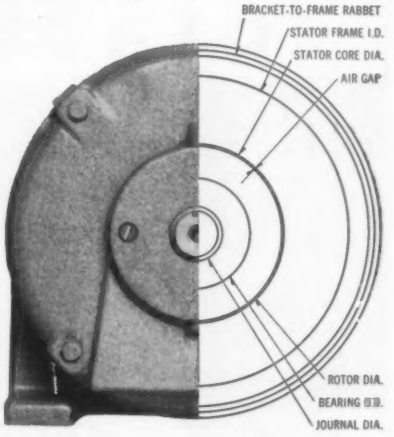
A MOTOR IS A SERIES OF CIRCLES

Checking bracket rabbet of an Elliott C-W Motor

The smooth, quiet, cool operation of Elliott Crocker-Wheeler motors is a direct result of the accuracy and concentricity of the "circles" that are its most important dimensions. Some of these circles are identified in the drawing below.

The bracket rabbet is a reference for bearing bore and shaft bore. Through matching jigs, the rabbets and bores of the stator are made accurately concentric with the bracket. Thus, when the motor is assembled, the series of concentric circles has been accurately established. With all parts in alignment, there is no preloading of bearings, air gap is uniform, noise is minimized, heat transfer expedited, smooth, trouble-free operation assured.

The highly-perfected, precision manufacturing processes by which Elliott achieves this vital concentricity are described by a booklet, *The Fine Art of Building Better Motors.* We will be happy to send you a copy. Contact nearest Elliott office, or write Crocker-Wheeler Division, Elliott Company, Jeannette, Pa.



Precise fit and concentricity of brackets to frame, frame to core, shaft to rotor and bearings, and bearings to brackets gives Elliott C-W Motors long life, trouble-free operation.

Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including EPA•SEAL the epoxy insulation used where conditions are very severe. WI-4

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for strong high alloy requirements in the 1,800° to 2,300° F range!

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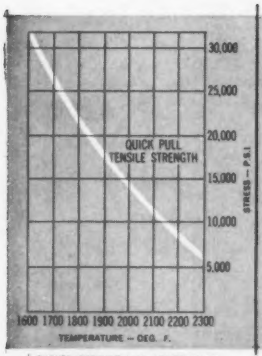
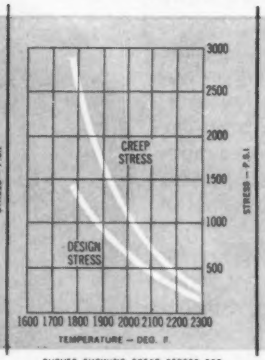


CURVES SHOWING HIGH TEMPERATURE SHORT-TIME TENSILE STRENGTH OF DURALOY-HOM



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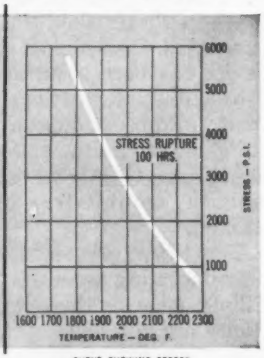

CURVE SHOWING STRESS TO RUPTURE AT 100 HOURS FOR DURALOY-HOM

Castings of DURALOY "HOM" are now being produced by our three methods: static, centrifugal and shell molded. Write today for additional information on this versatile new alloy.

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Send for bulletins, application data sheets and teletype computer load sheets.

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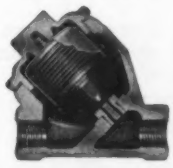

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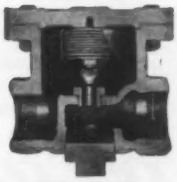
Tight Shut-off



TYPE B-250

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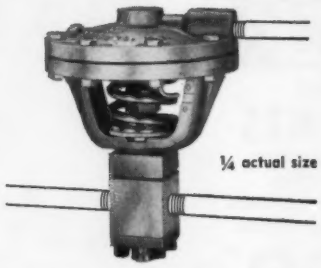

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If suitable barstock material is available, any problem fluid can be throttled or provided with positive on-off control. Dahl BANTAM Control Valves, featuring barstock bodies, handle any chemical fluid except liquid metals like sodium and similar fluids where excessive temperature is a restriction.

BANTAM features include excellent flow characteristics, low hysteresis, and fast response. Offered in a wide selection of pneumatic operators and control positioners, standard models are rated at pressures up to 1000 psi at 450°F. Compactness, quality construction, and ruggedness also contribute to their virtually unlimited application versatility.

REQUEST Catalog B-1 for complete data on these versatile valves . . . for positive control of your problem fluids! G. W. Dahl Co., Inc., 85 Tupelo Street, Bristol, Rhode Island.

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Scam De-Line annunciators, your systems' sentry, now offers the new MAGNA-PLAC nameplate which provides 70% more engraving area.

The MAGNA-PLAC nameplate gives the engineer increased space to more accurately describe condition variations or to employ larger characters for greater visibility. It is interchangeable with standard Scam nameplates and optionally available *without extra charge.*

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Yes, continuous product improvements such as MAGNA-PLAC, flexible application, ruggedness and reliability are what make De-Line the engineer's annunciator.

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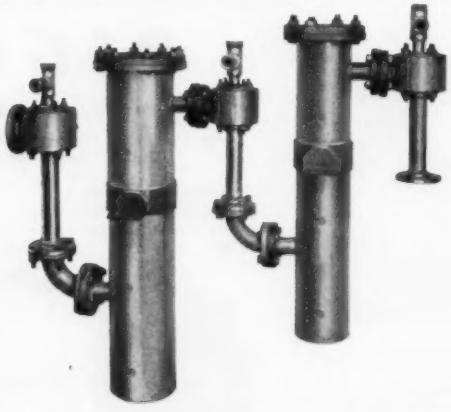

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Like this 3-stage Jet-Vac ejector, for example. Its stainless steel constructon affords better internal and external corrosion resistance, lighter weight.

Jet-Vac ejectors can be made with super alloys, many other special corrosion resistant materials which give a new measure of protection for handling corrosive fluids.

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Available in all ASA Standard sizes and pressures.

See pages 36-41 of Lenape General Catalog for full details and specifications. Write for your copy.

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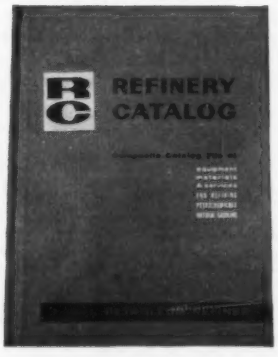
RASCHIG RINGS
for tower packing

See PAGE 289 in the REFINERY CATALOG



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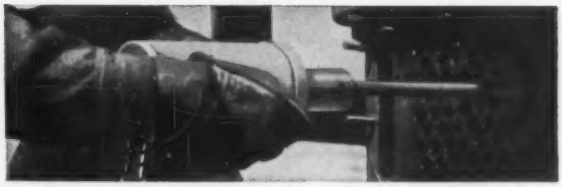

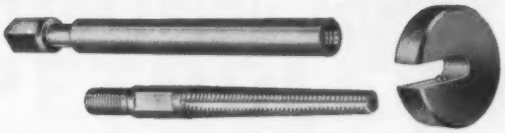

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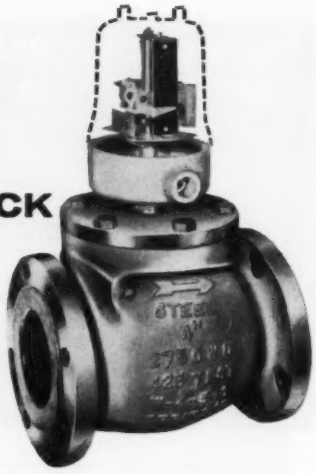

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AND

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BY

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DEPENDABLE AS THE PULL OF A MAGNET

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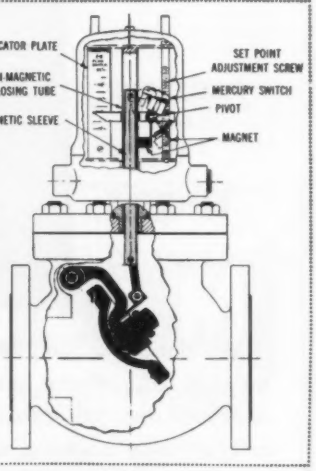

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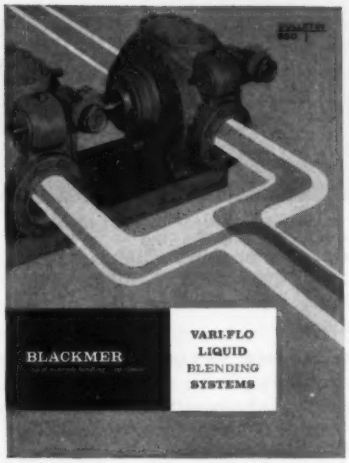

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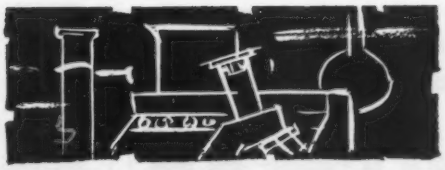

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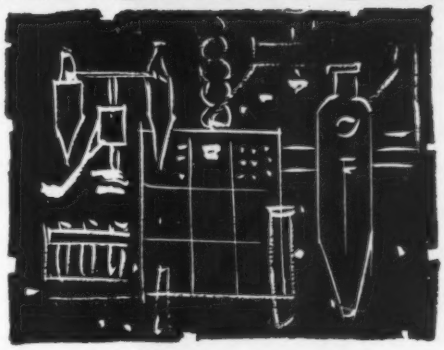

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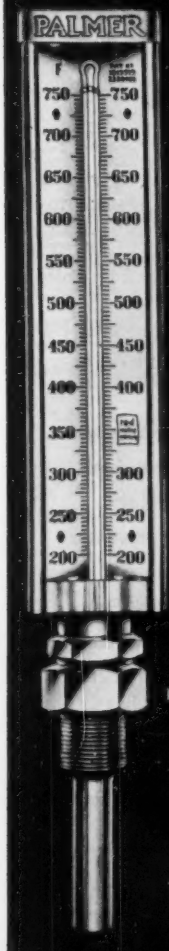

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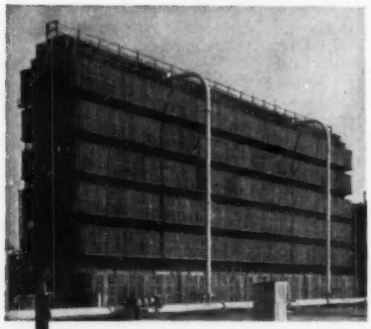

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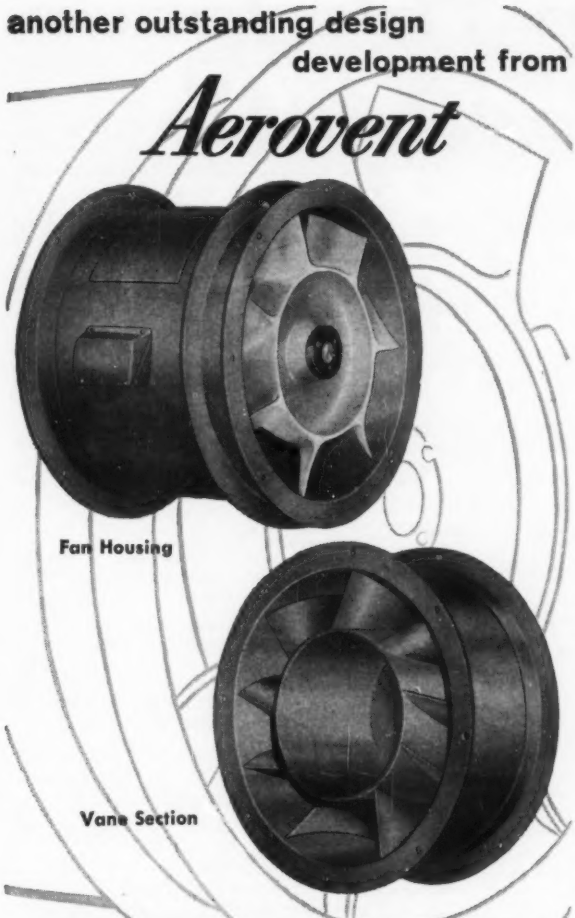

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- Designed to withstand rugged field conditions.
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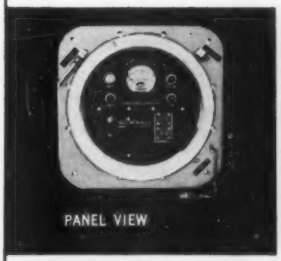

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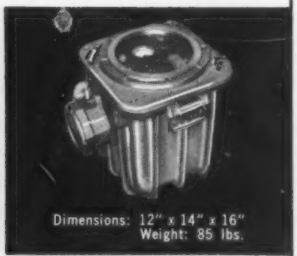

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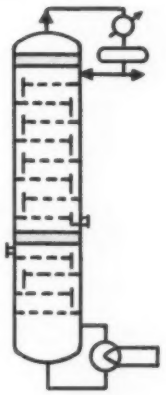

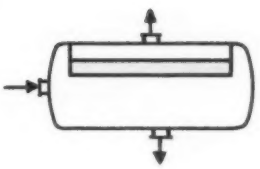

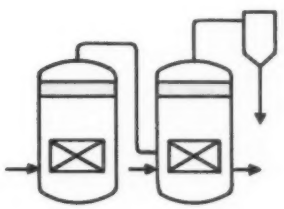

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